SUPPLEMENT

TO THE THIRD EDITION OF THE

ENCYCLOPÆDIA BRITANNICA,

OR

DICTIONARY

OF

ARTS, SCIENCES,

AND

MISCELLANEOUS LITERATURE.

IN TWO VOLUMES.

Illustrated with Fifty Copperplates.

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NON IGNORO, QUÆ BONA SINT, FIERI MELIORA POSSE DOCTRINA, ET QUÆ NON OPTIMA, ALIQUO MODO ACUI TAMEN, ET CORRIGI POSSE.—*Cicero.*

VOL. II

Edinburgh:
PRINTED FOR THOMSON BONAR, PARLIAMENT-SQUARE,
BY *JOHN BROWN*, ANCHOR CLOSE, EDINBURGH.

1801.

[Entered in Stationers Hall.]

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Increment, Indeterminate.

INCREMENT, is the ſmall increaſe of a variable quantity. Newton, in his Treatiſe on Fluxions, calls theſe by the name *Moments;* and obſerves, that they are proportional to the velocity or rate of increaſe of the flowing or variable quantities in an indefinitely ſmall time. He denotes them by ſubjoining a cypher o to the flowing quantity whoſe moment or increment it is; thus, xo the moment of x. In the doctrine of Increments, by Dr Brooke Taylor and Mr Emerſon, they are denoted by points below the variable quantities; as $\underset{.}{x}$. Some have alſo denoted them by accents underneath the letter, as $\underset{'}{x}$; but it is now more uſual to expreſs them by accents over the ſame letter; as x'.

METHOD OF INCREMENTS, a branch of Analytics, in which a calculus is founded on the properties of the ſucceſſive values of variable quantities, and their differences or increments.

The inventor of the method of increments was the learned Dr Taylor, who, in the year 1715, publiſhed a treatiſe upon it; and afterwards gave ſome farther account and explication of it in the Philoſ. Tranſ. as applied to the finding of the ſums of ſeries. And another ingenious and eaſy treatiſe on the ſame, was publiſhed by Mr Emerſon, in the year 1763. The method is nearly allied to Newton's Doctrine of Fluxions, and ariſes out of it. Alſo the Differential method of Mr Stirling, which he applies to the ſummation and interpolation of ſeries, is of the ſame nature as the method of increments, but not ſo general and extenſive.

INDETERMINATE PROBLEM. See ALGEBRA, Part I Chap VI. *Encycl.*

Diophantus was the firſt writer on indeterminate problems, which, after the publication of his work in 1621 by Bachet, employed much of the time of the moſt celebrated mathematicians in Europe. Afterwards ſuch problems were neglected as uſeleſs, till the public attention was again drawn to them by Euler and la Grange. The example of ſuch men was followed by Mr John Leſlie, a very eminent and ſelf-taught mathematician; who, in the ſecond vol. of the Tranſactions of the Royal Society of Edinburgh, has publiſhed an ingenious paper on indeterminate problems, reſolving them by a new and general principle. "The doctrine of indeterminate equations (ſays Mr Leſlie) has been ſeldom treated in a form equally ſyſtematic with the other parts of algebra. The ſolutions commonly given are devoid of uniformity, and often require a variety of aſſumptions. The object of this paper is to reſolve the complicated expreſſions which we obtain in the ſolution of indeterminate problems, into ſimple equations, and to do ſo, without framing a number of aſſumptions, by help of a ſingle principle, which, though extremely ſimple, admits of a very extenſive application.

Indeterminate, Induction.

"Let $A \times B$ be any compound quantity equal to another, $C \times D$, and let m be any rational number aſſumed at pleaſure; it is manifeſt that, taking equimultiples, $A \times m\,B = C \times m\,D$. If, therefore, we ſuppoſe that $A = mD$, it muſt follow that $mB = C$, or $B = \frac{C}{m}$. Thus two equations of a lower dimenſion are obtained. If theſe be capable of farther decompoſition, we may aſſume the multiples n and p, and form four equations ſtill more ſimple. By the repeated application of this principle, an higher equation, admitting of diviſors, will be reſolved into thoſe of the firſt order, the number of which will be one greater than that of the multiples aſſumed."

For example, reſuming the problem at firſt given, viz. to find two rational numbers, the difference of the ſquares of which ſhall be a given number. Let the given number be the product of a and b; then by hypotheſis, $x^2 - y^2 = ab$; but theſe compound quantities admit of an eaſy reſolution, for $\overline{x+y} \times \overline{x-y} = a \times b$. If, therefore, we ſuppoſe $x + y = ma$, we ſhall obtain $x - y = \frac{b}{m}$; where m is arbitrary, and if rational, x and y muſt alſo be rational. Hence the reſolution of theſe two equations gives the values of x and y, the numbers ſought, in terms of m; viz.

$$x = \frac{m^2a + b}{2m}, \text{ and } y = \frac{m^2a - b}{2m}.$$

INDUCTION, in logic, is that proceſs of the underſtanding by which from a number of *particular* truths perceived by ſimple apprehenſion, and diligently compared together, we infer another truth which is always *general* and ſometimes *univerſal.* It is perhaps needleſs to obſerve, that in the proceſs of induction the truths to be compared muſt be of the ſame kind, or relate to objects having a ſimilar nature; for the mereſt tyro in ſcience

Induction. science knows that physical truths cannot be compared with moral truths, nor the truths of pure mathematics with either.

That the method of induction is a just logic, has been sufficiently evinced elsewhere (see LOGIC, Part III. chap. V. and PHILOSOPHY, n° 73—78. *Encycl.*), and is now indeed generally admitted. It is even admitted by British philosophers to be the only method of reasoning by which any progress can be made in the physical sciences; for the laws of Nature can be discovered only by accurate experiments, and by carefully noting the agreements and the differences, however minute, which are thus found among the phenomena apparently similar. It is not, however, commonly said that *induction* is the method of reasoning employed by the mathematicians; and the writer of this article long thought, with others, that in pure geometry the reasoning is strictly *syllogistical*. Mature reflection, however, has led him to doubt, with Doctor Reid *, the truth of the generally received opinion, to doubt even whether by categorical syllogisms any thing whatever can be proved. the idolaters of Aristotle we are perfectly aware that this will appear an extravagant paradox; but to the votaries of truth, we do not despair of making it very evident, that for such doubts there is some foundation.

* Appendix to Vol. III of *Sketches of the History of Man.*

We are led into this disquisition to counteract, in some degree, what we think the pernicious tendency of the philosophy of Kant, which attempts have been lately made to introduce into this country. Of this philosophy we shall endeavour to give something like a distinct view in the proper place. It is sufficient to observe here, that it rests upon the hypothesis, that "we are in possession of certain notions *à priori*, which are absolutely *independent of all experience*, although the *objects of experience* correspond with them; and which are distinguished by *necessity* and strict *universality*." These innate and universal notions, Kant considers as a set of *categories*, from which is to be deduced all such knowledge as deserves the name of science; and he talks, of course, or at least his English translators represent him talking, with great contempt, of inductive reasoning, and substituting syllogistic demonstration in its stead.

As his categories are not familiar to our readers, we shall, in this place, examine syllogisms connected with the categories of Aristotle, which are at least more intelligible than those of Kant, and which, being likewise general notions, must, in argument, be managed in the same way. Now the fundamental axiom upon which every categorical syllogism rests, is the well known proposition, which affirms, that "whatever may be predicated of a whole *genus*, may be predicated of every *species* and of every *individual* comprehended under that genus." This is indeed an undoubted truth; but it cannot constitute a foundation for reasoning from the *genus* to the *species* or the *individual*; because we cannot possibly know what can be predicated of the *genus* till we know what can be predicated of all the *individuals* ranged under it. Indeed it is only by ascertaining, through the medium of induction, what can be predicated, and what not, of a number of individuals, that we come to form such notions as those of *genera* and *species*; and therefore, in a syllogism strictly categorical, the propositions, which constitute the *premises*, and are taken for granted, are those alone which are capable of proof; whilst the conclusion, which the logician pretends to demonstrate, must be evident to intuition or experience, otherwise the premises could not be known to be true. The analysis of a few syllogisms will make this apparent to every reader.

Dr Wallis, who, to an intimate acquaintance with the Aristotelian logic, added much mathematical and physical knowledge, gives the following syllogism as a perfect example of this mode of reasoning in the first figure, to which it is known that all the other figures may be reduced:—

> *Omne animal* est *sensu præditum.*
> *Socrates* est *animal.* Ergo
> *Socrates* est *sensu præditus.*

Here the proposition to be demonstrated is, that Socrates is endowed with sense; and the propositions assumed as self-evident truths, upon which the demonstration is to be built, are, that "every animal is endowed with sense;" and that "Socrates is an animal." But how comes the demonstrator to know that "every animal is endowed with sense?" To this question we are not aware of any answer which can be given, except this, that mankind have agreed to call every being, which they perceive to be endowed with sense, an *animal*. Let this, then, be supposed the true answer: the next question to be put to the demonstrator is, How he comes to know that *Socrates* is an *animal?* If we have answered the former question properly, or, in other words, if it be essential to this genus of beings to be endowed with sense, it is obvious that he can know that Socrates is an *animal* only by perceiving him to be *endowed with sense*; and therefore, in this syllogism, the proposition to be proved is the very first of the three of which the truth is perceived; and it is perceived intuitively, and not inferred from others by a process of reasoning.

Though there are ten categories and five predicables, there are but two kinds of categorical propositions, viz. Those in which the property or accident is predicated of the substance to which it belongs, and those in which the *genus* is predicated of the *species* or *individual*. Of the former kind is the proposition pretended to be proved by the syllogism which we have considered; of the latter, is that which is proved by the following:

> Quicquid sensu præditum, est animal.
> Socrates est sensu præditus. Ergo
> Socrates est animal.

That this is a categorical syllogism, legitimate in mode and figure, will be denied by no man who is not an absolute stranger to the very first principles of the Aristotelian logic; but it requires little attention indeed to perceive that it proves nothing. The imposition of names is a thing so perfectly arbitrary, that the being, or class of beings, which in Latin and English is called *animal*, is with equal propriety in Greek called ζωον, and in Hebrew נפש. To a native of Greece, therefore, and to an ancient Hebrew, the major proposition of this syllogism would have been wholly unintelligible; but had either of those persons been told by a man of known veracity, and acquainted with the Latin tongue, that every thing endowed with sense was, by the Romans, called *animal*, he would then have understood the proposition, admitted its truth without hesitation, and have henceforth

henceforth known that Socrates and Moses, and every thing else which he perceived to be endowed with sense, would at Rome be called *animal.* This knowledge, however, would not have rested upon demonstrative reasoning of any kind, but upon the credibility of his informer, and the intuitive evidence of his own senses.

It will perhaps be said, that the two syllogisms which we have examined are improper examples, because the truth to be proved by the former is self evident, whilst that which is meant to be established by the latter is merely verbal, and therefore arbitrary. But the following is liable to neither of these objections:

All animals are *mortal.*
Man is *an animal*; therefore
Man is *mortal.*

Here it would be proper to ask the demonstrator, upon what grounds he so confidently pronounces all animals to be mortal? The proposition is so far from expressing a self evident truth, that, previous to the entrance of sin and death into the world, the first man had surely no conception of mortality. He acquired the notion, however, by experience, when he saw the animals die in succession around him; and when he observed that no animal with which he was acquainted, not even his own son, escaped death, he would conclude that all animals, without exception, are mortal. This conclusion, however, could not be built upon syllogistic reasoning, nor yet upon intuition, but partly upon experience and partly on analogy. As far as his experience went, the proof, by induction, of the mortality of all animals was complete; but there are many animals in the ocean, and perhaps on the earth, which he never saw, and of whose mortality therefore he could affirm nothing but from analogy, *i. e.* from concluding, as the constitution of the human mind compels us to conclude, that Nature is uniform throughout the universe, and that similar causes, whether known or unknown, will, in similar circumstances, produce, at all times, similar effects. It is to be observed of this syllogism, as of the first which we have considered, that the proposition, which it pretends to demonstrate, is one of those truths known by experience, from which, by the process of induction, we infer the major of the premises to be true; and that therefore the reasoning, if reasoning it can be called, runs in a circle.

Yet by a concatenation of syllogisms have logicians pretended that a long series of important truths may be discovered and demonstrated; and even Wallis himself seems to think, that this is the instrument by which the mathematicians have deduced, from a few postulates, accurate definitions, and undeniable axioms, all the truths of their demonstrative science. Let us try the truth of this opinion by analysing some of Euclid's demonstrations.

In the short article PRINCIPLE (*Encycl.*), it has been shewn, that all our *first* truths are *particular*, and that it is by applying to them the rules of induction that we form general truths or axioms—even the axioms of pure geometry. As this science treats not of real external things, but merely of *ideas* or *conceptions*, the creatures of our minds, it is obvious, that its definitions may be perfectly accurate, the induction by which its axioms are formed complete, and therefore the axioms themselves *universal* propositions. The use of these axioms is merely to shorten the different processes of geometrical reasoning, and not, as has sometimes been absurdly supposed, to be made the *parents* or *causes* of *particular* truths. No truth, whether general or particular, can, in any sense of the word, be the cause of another truth. If it were not true that all individual figures, of whatever form, comprehending a portion of space equal to a portion comprehended by any other individual figure, whether of the same form with some of them, or of a form different from them all, are equal to one another, it would not be true that "things in *general*, which are equal to the same thing, or that magnitudes which coincide, or exactly fill the same space," are respectively equal to one another; and therefore the first and eight of Euclid's axioms would be false. So far are these axioms, or general truths, from being the parents of particular truths, that, as conceived by us, they may, with greater propriety, be termed their *offspring*. They are indeed nothing more than general expressions, comprehending all particular truths of the same kind. When a mathematical proposition therefore is enounced, if the terms, of which it is composed, or the figures of which a certain relation is predicated, can be brought together and immediately compared, no demonstration is necessary to point out its truth or falsehood. It is indeed intuitively perceived to be either comprehended under, or contrary to some known *axiom* of the science; but it has the evidence of truth or falsehood *in* itself, and not in *consequence* of that axiom. When the figures or symbols cannot be immediately compared together, it is then, and only then, that recourse is had to demonstration; which proceeds, not in a series of syllogisms, but by a process of ideal mensuration or induction. A figure or symbol is conceived, which may be compared with each of the principal figures or symbols, or, if that cannot be, with one of them, and then another, which may be compared with it, till through a series of well known intermediate relations, a comparison is made between the terms of the original proposition, of which the truth or falsehood is then perceived.

Thus in the 47th proposition of the first book of Euclid's Elements, the author proposes to demonstrate the equality between the square of the hypothenuse of a right angled triangle, and the sum of the squares described on the other two sides; but he does not proceed in the way of categorical syllogisms, by raising his demonstration on some universal truth relating to the *genus* of *squares*. On the contrary, he proceeds to *measure* the three squares of which he has affirmed a certain relation; but as they cannot be immediately compared together, he directs the largest of them to be divided into two parallelograms, according to a rule which he had formerly ascertained to be just; and as these parallelograms can, as little as the square of which they are the constituent parts, be compared with the squares of the other two sides of the triangle, he thinks of some intermediate figure which may be applied as a common measure to the squares and the parallelograms. Accordingly, having before found that a parallelogram, or square, is exactly double of a triangle standing on the same base and between the same parallels with it, he constructs triangles upon the same base, and between the same parallels with his parallelograms, and the squares of the sides containing the right angle of the original triangle; and finding, by a process formerly shewn to be just,

that the triangles on the bases of the parallelograms are precisely equal to the triangles on the bases of the squares, he perceives at once that the two parallelograms, of which the largest square is composed, must be equal to the sum of the two lesser squares; and the truth of the proposition is demonstrated.

In the course of this demonstration, there is not so much as one truth *inferred* from another by *syllogism*; but all are perceived in succession by a series of simple apprehensions. Euclid, indeed, after finding the triangle constructed on the base of one of the parallelograms to be equal to the triangle constructed on the base of one of the squares, introduces an *axiom*, and says, "but the doubles of equals are equal to one another; *therefore* the parallelogram is equal to the square." But if from this mode of expression any man conceive the axiom or universal truth to be the *cause* of the truth more particular, or suppose that the *latter* could not be apprehended without a *previous* knowledge of the former, he is a stranger to the nature of evidence, and to the process of *generalization*, by which axioms are formed.

If we examine the problems of this ancient geometrician, we shall find that the truth of them is proved by the very same means which he makes use of to point [illegible] the truth of his theorems. Thus, the first problem of his immortal work is, "to describe an equilateral triangle on a given finite straight line;" and not only is this to be done, but the method by which it is done must be such as can be shewn to be incontrovertible, [illegible] The sides of a triangle, however, cannot be applied to each other so as to be immediately compared; for they are conceived to be immoveable among themselves. A common measure, therefore, or something equivalent to a common measure, must be found, by which the triangle may be constructed, and the equality of its three sides afterwards evinced; and this equivalent Euclid finds in the *circle*.

By contemplating the properties of the circle, it was easy to perceive that all its *radii* must be equal to one another. He therefore directs two circles to be described from the opposite extremities of the given finite straight line, so as that it may be the radius of each of them; and from the point in which the circles intersect one another, he orders lines to be drawn to the extreme points of the given line, affirming that these three lines constitute an equilateral triangle. To convince his reader of the truth of this affirmation, he has only to put him in mind, that from the properties of the circle, the lines which he has drawn must be each equal to the given line, and of course all the three equal to one another; and this mutual equality is perceived by simple apprehension, and not inferred by syllogistic reasoning. Euclid, indeed, by introducing into the demonstration his first axiom, gives to it the form of a syllogism: but that syllogism proves nothing; for if the equality of the three sides of the triangle were not intuitively perceived in their position and the properties of the circle, the first axiom would itself be a falsehood. So true it is that categorical syllogisms have no place in geometrical reasoning; which is as strictly experimental and inductive as the reasoning employed in the various branches of physics.

But if this be so, how come the truths of pure geometry to be necessary, so that the contrary of any one of them is clearly perceived to be impossible; whilst physical truths are all contingent, so that there is not one of them of which the direct contrary may not easily be conceived?

That there is not one physical truth, of which the contrary may not be conceived, is not perhaps so certain as has generally been imagined; but admitting the fact to be as it has commonly been stated, the apparent difference between this class of truths and those of pure geometry, may be easily accounted for, without supposing that the former rests upon a kind of evidence totally different from that which supports the fabric of the latter.

The objects of pure geometry, as we have already observed, are the creatures of our own minds, which contain in them nothing concealed from our view. As the mathematician treats them merely as measurable quantities, he knows, with the utmost precision, upon what particular properties the relation affirmed to subsist between any two or more of them must absolutely depend; and he cannot possibly entertain a doubt but it will be found to have place among all quantities having the same properties, because it depends upon them, and upon them alone. His process of induction, therefore, by a series of ideal measurements, is always complete, and exhausts the subject; but in physical enquiries the case is widely different. The subjects which employ the physical enquirer are not his own ideas, and their various relations, but the properties, powers, and relations of the bodies which compose the universe; and of those bodies he knows neither the substance, internal structure, nor all the qualities: so that he can very seldom discover with certainty upon what particular property or properties the phenomena of the corporeal world, or the relations which subsist among different bodies, depend. He expects, indeed, with confidence, not inferior to that with which he admits a mathematical demonstration, that any corporeal phenomenon, which he has observed in certain circumstances, will be always observed in circumstances exactly similar; but the misfortune is, that he can very seldom be ascertained of this similarity. He does not know any one piece of matter *as it is in itself*; he cannot separate its various properties; and of course cannot attribute to any one property the effects or apparent effects which proceed exclusively from it. Indeed, the properties of bodies are so closely interwoven, that by human means they cannot be completely separated; and hence the most cautious investigator is apt to attribute to some one or two properties, an event which in reality results perhaps from many. (See PHILOSOPHY and PHYSICS, *Encycl.*) This the geometrician never does. He knows perfectly that the relation of equality which subsists between the three angles of a plain triangle and two right angles, depends not upon the size of the triangles, the matter of which they are conceived to be made, the particular place which they occupy in the universe, or upon any one circumstance whatever besides their triangularity, and the angles of their correlets being exactly right angles; and it is upon this power of discrimination which we have in the conceptions of pure geometry, and have not in the objects of physics, that the truths of the one science are perceived to be necessary, while those of the other appear to be contingent; though the mode of demonstration is the same

Inertia, Inflammation.

same in both, or at least equally removed from categorical syllogisms.

INERTIA. See Dynamics and Impulsion in this *Supplement*.

INFLAMMATION has been sufficiently explained in the *Encyclopædia*, and in the article Chemistry in this *Supplement*; but it cannot be improper, in this place, to give an account of some remarkable

Spontaneous Inflammations, which, as different substances, are liable to them, have been, and may again be, the cause of many and great misfortunes.

The spontaneous inflammation of essential oils, and that of some fat oils, when mixed with nitrous acid, are well known to philosophers; so also is that of powdered charcoal with the same acid (lately discovered by M. Proust), and those of phosphorus, of pyrophorus, and of fulminating gold. These substances are generally to be found only in the laboratories of chemists, who are perfectly well acquainted with the precautions which it is necessary to take to prevent the unhappy accidents which may be occasioned by them.

The burning of a store-house of sails, which happened at Brest in the year 1757, was caused by the spontaneous inflammation of some oiled cloths, which, after having been painted on one side, and dried in the sun, were stowed away while yet warm; as was shewn by subsequent experiments *.

* See *Memoires de l'Academie de Paris*, 1760.

Vegetables boiled in oil or fat, and left to themselves, after having been pressed, inflame in the open air. This inflammation always takes place when the vegetables retain a certain degree of humidity; if they are first thoroughly dried, they are reduced to ashes, without the appearance of flame. We owe the observation of these facts to MM. Saladin and Carette †.

The heaps of linen rags which are thrown together in paper manufactories, the preparation of which is hastened by means of fermentation, often take fire, if not carefully attended to.

The spontaneous inflammation of hay has been known for many centuries; by its means houses, barns, &c. have been often reduced to ashes. When the hay is laid up damp, the inflammation often happens; for the fermentation is then very great. This accident very seldom occurs to the first hay (according to the observation of M. de Bomare), but is much more common to the second; and if, through inattention, a piece of iron should be left in a stalk of hay in fermentation, the inflammation of that stalk is almost a certain consequence. Corn heaped up has also sometimes produced inflammations of this nature. Vanieri, in his *Prædium Rusticum*, says,

Quæ vero (gramina) nondum satis insolata recondens
Imprudens, subitis pariunt incendia flammis.

Dung also, under certain circumstances, inflames spontaneously.

In a paper, published in the *Repertory of Arts and Manufactures*, by the Rev. William Tooke, F. R. S. &c. we have the following remarkable instances of spontaneous inflammation. "A person of the name of Rude, an apothecary at Bautzen, had prepared a pyrophorus from rye-bran and alum. Not long after he had made the discovery, there broke out, in the next village of Nauslitz, a great fire, which did much mischief, and was said to have been occasioned by the treating of a sick cow in the cow-house. Mr Rude knew, that the countrymen were used to lay an application of parched rye-bran to their cattle curing the thick neck: he knew also, that alum and rye bran, by a proper process, yielded a pyrophorus; and now he wished to try whether parched rye bran alone would have the same effect. Accordingly, he roasted a quantity of rye-bran by the fire, till it had acquired the colour of roasted coffee. This roasted bran he wrapped up in a linen cloth; in the space of a few minutes there arose a strong smoke through the cloth, accompanied by a smell of burning. Not long afterwards the rag grew as black as tinder, and the bran, now become hot, fell through it on the ground in little balls. Mr Rude repeated the experiment at various times, and always with the same result. Who now will any longer doubt, that the frequency of fires in cow-houses, which in those parts are mostly wooden buildings, may not be occasioned by this common practice, of binding roasted bran about the necks of the cattle? The fire, after consuming the cattle and the shed, communicates itself to the adjoining buildings; great damage ensues; and the ignorant look for the cause in wilful and malicious firing, consequently in a capital crime."

The same author informs us, that in the spring of the year 1780, a fire was discovered on board a Russian frigate lying in the road of Cronstadt; which, if it had not been timely extinguished, would have endangered the whole fleet. After the severest scrutiny, no cause of the fire was to be found; and the matter was forced to remain without explanation, but with strong surmises of some wicked incendiary being at the bottom of it. In the month of August, in the same year, a fire broke out at the hemp-magazine at St Petersburgh, by which several hundred thousand poods ‡ of hemp and flax were consumed. The walls of the magazine are of brick, the floors of stone, and the rafters and covering of iron; it stands alone on an island in the Neva, on which, as well as on board the ships lying in the Neva, no fire is permitted. In St Petersburgh, in the same year, a fire was discovered in the vaulted shop of a furrier. In these shops, which are all vaults, neither fire nor candle is allowed, and the doors of them are all of iron. At length the probable cause was found to be, that the furrier, the evening before the fire, had got a roll of new cere-cloth (much in use here for covering tables, counters, &c. being easily wiped and kept clean), and had left it in his vault, where it was found almost consumed.

‡ A pood consists of 40 pounds Russ, or 36 English.

In the night between the 20th and 21st of April 1781, a fire was seen on board the frigate Maria, which lay at anchor, with several other ships, in the road off the island of Cronstadt; the fire was, however, soon extinguished; and, by the severest examination, little or nothing could be extorted concerning the manner in which it had arisen. The garrison was threatened with a scrutiny that should cost them dear; and while they were in this cruel state of suspence, an order came from the sovereign, which quieted their minds, and gave rise to some very satisfactory experiments.

It having been found, upon juridical examination, as well as private inquiry, that in the ship's cabin, when the smoke appeared, there lay a bundle of matting, containing Russian lamp-black prepared from fir-soot, moistened with hemp oil varnish, which was perceived

Inflammation. to have sparks of fire in it at the time of the extinction, the Russian admiralty gave orders to make various experiments, in order to see whether a mixture of hemp-oil varnish and the forementioned Russian black, folded up in a mat and bound together, would kindle of itself.

They shook 40 pounds of fir-wood soot into a tub, and poured about 35 pounds of hemp oil varnish upon it; thus they let stand for an hour, after which they poured off the oil. The remaining mixture they now wrapped up in a mat, and the bundle was laid close to the cabin, where the midshipmen had their birth. To avoid all suspicion of treachery, two officers sealed both the mat and the door with their own seals, and stationed a watch of four sea officers, to take notice of all that passed the whole night through; and as soon as any smoke should appear, immediately to give information to the commandant of the port.

The experiment was made the 26th of April, about 11 o'clock A. M. in presence of all the officers named in the commission. Early on the following day, about six o'clock A. M. a smoke appeared, of which the chief commandant was immediately informed by an officer: he came with all possible speed, and through a small hole in the door saw the mat smoking. Without opening the door, he dispatched a messenger to the members of the commission; but as the smoke became stronger, and fire began to appear, the chief commandant found it necessary, without waiting for the members of the commission to break the seals and open the door. No sooner was the air thus admitted, than the mat began to burn with greater force, and presently it burst into a flame.

The Russian admiralty, being now fully convinced of the self-enkindling property of this composition, transmitted their experiment to the Imperial Academy of Sciences; who appointed Mr Georgi, a very learned and able adjunct of the academy, to make farther experiments on the subject. Previous to the relation of these experiments, it is necessary to observe, that the Russian fir-black is three or four times more heavy, thick, and unctuous, than that kind of painters black which the Germans call *kien rahm*. The former is gathered at Ochta, near St Petersburgh, at Mosco, at Archangel, and other places, in little wooden huts, from resinous fir-wood, and the unctuous bark of birch, by means of an apparatus uncommonly simple, consisting of pots without bottoms set one upon the other; and is sold very cheap. The famous fine German *kien-rahm* is called in Russia *Holland's black*. In what follows, when raw oil is spoken of, it is to be understood of linseed-oil or hemp oil; but most commonly the latter. The varnish is made of five pounds of hemp-oil boiled with two ounces and a half of minium. For wrapping up the composition, Mr Georgi made use of coarse hemp-linen, and always single, never double. The impregnations and commixtures were made in a large wooden bowl, in which they stood open till they were wrapped up in linen.

Three pounds of Russian fir-black were slowly impregnated with five pounds of hemp-oil varnish; and when the mixture had stood open five hours, it was bound up in linen. By this process it became clotted; but some of the black remained dry. When the bundle had lain sixteen hours in a chest, it was observed to emit a very nauseous, and rather putrid, smell, not quite unlike that of boiling oil. Some parts of it became warm, and steamed much; this steam was watery, and by no means inflammable. Eighteen hours after the mixture was wrapped up, one place became brown, emitted smoke, and directly afterwards glowing fire appeared. The same thing happened in a second and a third place, though other places were scarcely warm. The fire crept slowly around, and gave a thick, grey, stinking smoke. Mr Georgi took the bundle out of the chest, and laid it on a stone pavement; when, on being exposed to the free air, there arose a slow burning flame, a span high, with a strong body of smoke. Not long afterwards there appeared, here and there, several chaps or clefts, as from a little volcano, the vapour issuing from which burst into flame. On his breaking the lump, it burst into a very violent flame, full three feet high, which soon grew less, and then went out. The smoking and glowing fire lasted for the space of six hours; and afterwards the remainder continued to glow without smoke for two hours longer. The grey earthy ashes, when cold, weighed five ounces and a half.

In another experiment, perfectly similar to the foregoing, as far as relates to the composition and quantities, the enkindling did not ensue till 41 hours after the impregnation: the heat kept increasing for three hours, and then the accension followed. It is worthy of remark, that these experiments succeeded better on bright days than on such as were rainy; and the accension came on more rapidly.

In another experiment, three pounds of Russian fir-black were slowly impregnated with three pounds of raw hemp-oil; and the accension ensued after nine hours.

Three quarters of a pound of German *rahm* were slowly impregnated with a pound and a half of hemp-oil varnish. The mixture remained 70 hours before it became hot and reeking: it then gradually became hotter, and emitted a strong exhalation; the effluvia were moist, and not inflammable. The reaction lasted 36 hours, during which the heat was one while stronger, and then weaker, and at length quite ceased.

Stove or chimney soot, mostly formed from birch-wood smoke, was mingled with the above-mentioned substances and tied up; the compound remained cold and quiet.

Russian fir-black, mixed with equal parts of oil of turpentine, and bound up, exhibited not the least reaction or warmth.

Birch oil, mixed with equal parts of Russian fir-black, and bound up, began to grow warm and to emit a volatile smell; but the warmth soon went off again.

From the experiments of the admiralty and of Mr Georgi, we learn, not only the decisive certainty of the self accension of soot and oil, when the two substances are mixed under certain circumstances, but also the following particulars:

Of the various kinds of soot, or lamp-black, the experiments succeeded more frequently and surely with the coarser, more unctuous, and heavier, like Russian painters black, than with fine light German rahm with coarse chimney-soot. In regard to oils, only those experiments succeeded which were made with drying oils, either raw or boiled. The proportions of the soots to the oils were, in the successful experiments, very various; the mixture kindled with a tenth, a fifth, a third, with

Inflammation.

with an equal, and likewise with a double, proportion of oil. In general, however, much more depends on the mode of mixture, and the manipulation, and, as Mr Georgi often observed, on the weather; for in moist weather the bundles, after becoming warm, would frequently grow cold again.

The instances of spontaneous inflammation hitherto mentioned have been only of vegetable substances; but we have examples of the same thing in the animal kingdom. Pieces of woollen cloth, which had not been scoured, took fire in a warehouse. The same thing happened to some heaps of woollen yarn; and some pieces of cloth took fire in the road, as they were going to the fuller. These inflammations always take place where the matters heaped up preserve a certain degree of humidity, which is necessary to excite a fermentation; the heat resulting from which, by drying the oil, leads them insensibly to a state of ignition; and the quality of the oil, being more or less deficcative, very much contributes thereto.

The woollen stuff prepared at Sevennes, which bears the name of Emperor's stuff, has kindled of itself, and burnt to a coal. It is not unusual for this to happen to woollen stuffs, when in hot summers they are laid in a heap in a room but little aired.

In June 1781, the same thing happened at a woolcomber's in a manufacturing town in Germany, where a heap of wool-combings, piled up in a close warehouse seldom aired, took fire of itself. This wool had been by little and little brought into the warehouse; and, for want of room, piled up very high, and trodden down, that more might be added to it. That this combed wool, to which, as is well known, rape-oil mixed with butter is used in the combing, burnt of itself, was sworn by several witnesses. One of them affirmed that, ten years before, a similar fire happened among the flocks of wool at a clothier's, who had put them into a cask, where they were rammed hard, for their easier conveyance. This wool burnt from within outwards, and became quite a coal; it was very certain that neither fire nor light had been used at the packing, consequently the above fires arose from similar causes. In like manner, very credible cloth-workers have certified, that, after they have bought wool that was become wet, and packed it close in their warehouse, this wool has burnt of itself; and very serious consequences might have followed, if it had not been discovered in time.

Nay, there are instances, though they be but rare, of human bodies being consumed by spontaneous inflammation. In the Philosophical Transactions, and in the Memoirs of the Academies of Paris and Copenhagen, it is related that an Italian lady (the Countess Cornelia Bandi) was entirely reduced to ashes, except her legs; that an English woman, called Grace Pitt, was almost entirely consumed by a spontaneous inflammation of her viscera: and, lastly, that a priest of Bergamo was consumed in the same manner. These spontaneous inflammations have been attributed to the abuse of spirituous liquors; but though the victims of intemperance are indeed very numerous, these certainly do not belong to that number.

The mineral kingdom also often affords instances of spontaneous inflammation. Pyrites heaped up, if wetted and exposed to the air, take fire. Pitcoal also, laid in heaps, under certain circumstances, inflames spontaneously.* M. Duhamel has described two inflammations of this nature, which happened in the magazines of Brest, in the years 1741 and 1757. Cuttings of iron, which had been left in water, and were afterwards exposed to the open air, gave sparks, and set fire to the neighbouring bodies. For this observation we are obliged to M. de Charpentier.

Inflammation || Ink.

The causes of these phenomena the chemist will assign; but they are here recorded as a warning to tradesmen and others. It is evident, from the facts which have been related, that spontaneous inflammations being very frequent, and their causes very various, too much attention and vigilance cannot be used to prevent their dreadful effects. And consequently it is impossible to be too careful in watching over public magazines and storehouses, particularly those belonging to the ordnance, or those in which are kept hemp, cordage, lampblack, pitch, tar, oiled cloths, &c. which substances ought never to be left heaped up, particularly if they have any moisture in them. In order to prevent any accident from them, it would be proper to examine them often, to take notice if any heat is to be observed in them, and, in that case, to apply a remedy immediately. These examinations should be made by day, it not being advisable to carry a light into the magazines; for when the fermentation is sufficiently advanced, the vapours which are disengaged by it are in an inflammable state, and the approach of a light might, by their means, set fire to the substances whence they proceed. Ignorance of the fore-mentioned circumstances, and a culpable negligence of those precautions which ought to be taken, have often caused more misfortunes and loss than the most contriving malice: it is therefore of great importance that these facts should be universally known, that public utility may reap from them every possible advantage.

INFORMED Stars, or Informes Stellæ, are such stars as have not been reduced into any constellation; otherwise called Sporades.—There was a great number of this kind left by the ancient astronomers; but Hevelius, and some others of the moderns, have provided for the greater part of them, by making new constellations.

Sympathetic INK is an old invention. Among the methods by which Ovid teaches young women to deceive their guardians, when they write to their lovers, he mentions that of writing with new milk, and of making the writing legible by coal dust or soot.

Tuta quoque est, fallitque oculos, e lacte recenti
Litera: carbonis pulvere tange, leges.

It is obvious, that any other colourless and glutinous juice, which will hold fast the black powder strewed over it, will answer the purpose as well as milk; and therefore Pliny recommends the milky juice of certain plants to be used.

There are several metallic solutions perfectly colourless, or, at least, without any strong tint, which being wrote with, the letters will not appear until the paper be washed over with another colourless solution, or exposed to the vapour of it; but among all these there is none which excites more astonishment, or from which naturalists can draw more conclusions, than that which consists of a solution of lead in vegetable acid, and which by the vapour of arsenical liver of sulphur becomes black, even at a considerable distance. This ink, which may

may be used by conjurors, proves the subtlety of vapour, and the porosity of bodies; as the change or colouring takes place even when the writing is placed on the other side of a thin wall.

We knew before, that a solution of lead, treated in this manner, would answer the purpose of a sympathetic ink (see that article *Encycl.*); but we did not know, nor do we yet believe, that the sulphuric vapours will act upon the writing through *a wall*. Such, however, is the affirmation of Professor Beckmann, who gives an account of a still more wonderful ink from Peter Borel. This author, in a book called *Hystoriarum et observationum medico physic. centuriæ quatuor*, printed at Paris, first in 1653, and afterwards in 1657, gives a receipt for making this ink, which he calls *magnetic waters which act at a distance*. The receipt is as follows:

"Let quick lime be quenched in common water, and while quenching, let some orpiment be added to it (this, however, ought to be done by placing warm ashes under it for a whole day), and let the liquor be filtered, and preserved in a glass bottle well corked. Then boil litharge of gold, well pounded, for half an hour with vinegar, in a brass vessel, and filter the whole through paper, and preserve it also in a bottle closely corked. If you write any thing with this last water, with a clean pen, the writing will be invisible when dry: but if it be washed over with the first water it will become instantly black. In this, however, there is nothing astonishing; but this is wonderful, that though sheets of paper without number, and even a board, be placed between the invisible writing and the second liquid, it will have the same effect, and turn the writing black, penetrating the wood and paper without leaving any traces of its action; which is certainly surprising; but a fetid smell, occasioned by the mutual action of the liquids, deters many from making the experiment. I am, however of opinion, that I could improve this secret by a more refined chemical preparation, so as that it should perform its effect through a wall. This secret (says Borel) I received, in exchange for others, from J. Brosson, a learned and ingenious apothecary of Montpelier."

For making a sympathetic ink of the fifth class mentioned in the *Encyclopædia*, the following process by M. Meyer may be worthy of the reader's notice. It was entered upon in consequence of a receipt for rose-coloured sympathetic ink shewn to him by a traveller. In that receipt cobalt was the principal ingredient, and therefore the first object was to procure cobalt; but M. Meyer, being unwilling to sacrifice pure pieces of cobalt of any considerable size, made choice of one, which was visibly mixed with bismuth, iron, and quartz. He endeavoured to separate the bismuth as much as possible, and also the arsenic, if it should contain any, by bringing it slowly to a red heat; and he succeeded pretty well, as the bismuth flowed from it in abundance; and the arsenic, the quantity of which was small, was volatilised: many globules of bismuth still adhered to it. By bringing it repeatedly to a red heat, and then quenching it in water, it was reduced to such a state as to be easily pulverised. Having poured nitrous acid upon the powder, he obtained by digestion a beautiful rose red solution; the siliceous earth was separated in the form of a white slime, and by diluting it with water there was deposited a white powder, which was oxyd of bismuth. The solution being filtered, he added to it a solution of potash, and obtained a precipitate inclining more to a yellow than to a red colour. He again poured over it a little of the nitrous acid, by which a part of the oxyd was re-dissolved of a red colour: the remaining part, which had a dark brown colour, was oxyd of iron. From the solution, by the addition of potash, a precipitate was formed, which was now reddish. Having by this process obtained it pure, that he might now prepare from it the wished for red ink, he dissolved the washen pure oxyd of cobalt in different acids. That dissolved in the nitrous acid with a mixture of nitre, gave a green ink like the common: that dissolved in the sulphurous acid, without the addition of salts, gave a reddish ink, which remained after it was exposed to heat, and would not again disappear, even when a solution of nitre was applied; and that dissolved in the muriatic acid, gave a green ink, darker and more beautiful than the common. By dissolving it, however, in the acetous acid, and adding a little nitre, he obtained what he had in view; for it gave, on the application of heat, an ink of a red colour, like that of the *rosa centifolia*, which again disappeared when the paper became cold.

Inordinate, Insects.

INORDINATE Proportion, is where the order of the terms compared is disturbed or irregular. As, for example, in two ranks of numbers, three in each rank, viz. in one rank, - - - - 2, 3, 9,
and in the other rank, 8, 24, 36
which are proportional, the former to the latter, but in a different order, viz. - - 2 : 3 :: 24 : 36,
and - - 3 : 9 :: 8 : 24.
then, casting out the mean terms in each rank, it is concluded that - - - - 2 : 9 :: 8 : 36,
that is, the first is to the 3d in the first rank,
as the first is to the 3d in the 2d rank.

INSECTS (See *Encycl.*). A number of non-descript little animals was discovered by La Martiniere the naturalist when accompanying Perouse on his celebrated voyage of discovery. These animals he called *insects*, and to many of them he gave particular names. Of these we shall give his description in this place, leaving our readers, as he has left his, to arrange them properly according to the Linnæan classification.

"The insect, which is figured N° 1. inhabits a small prismatic triangular cell, pointed at the two extremities, of the consistence and colour of clear brittle ice; the body of the insect is of a green colour, spotted with small bluish points, among which are some of a golden tinge; it is fixed by a ligament to the lower part of its small habitation: its neck is terminated by a small blackish head composed of three converging scales, in the form of a hat, and enclosed between three fins, two of them large and channelled in the upper part (A) and one small, semicircular (B). When it is disturbed, it immediately withdraws its fins and its head into its cell, and gradually sinks into the water by its own specific gravity. Fig. 2. represents the under side of the prism, shewing in what manner it is channelled, in order to allow free passage to the animal when it wishes to shut itself up in it. Fig. 3. represents the profile of the same. The movement carried on by the two larger fins, which are of a softish cartilaginous substance, may be compared to that which would be produced by the two hands joined together in the state of pronation, and forming, alternately, two inclined planes and one horizontal plane: it is by means of this motion that it supports itself on the top of the water, where it probably

Plate XXX.

Infects, Inftitute.

bly feed on fat and oily fubftances on the furface of the fea." Our author found it near Nootka, on the north-weft coaft of America, during a calm.

Fig. 4. reprefents a collection of infects, as our author calls them, confifting only of oval bodies, fimilar to a foap bubble, arranged in parties of three. five, fix, and nine: among them are alfo fome folitary ones. Thefe collections of globules, being put into a glafs filled with fea water, defcribed a rapid circle round the glafs by a common movement, to which each individual contributed by fimple compreffion of the fides of its body, probably the effect of the re-action of the air with which they were filled. It is not, however, eafy to conceive how thefe diftinct animals (for they may be readily feparated without deranging their economy) are capable of concurring in a common motion. "Thefe confiderations (fays our author), together with the form of the animal, recalled to my mind, with much fatisfaction, the ingenious fyftem of M. de Buffon; and I endeavoured to perfuade myfelf, that I was about to be witnefs to one of the moft wonderful phenomena of Nature, fuppofing that thefe molecules, which were now employed in increafing or diminifhing their number, or performing their revolutions in the glafs, would foon affume the form of a new animal of which they were the living materials. My impatience led me to detach two from the moft numerous group, imagining that this number might perhaps be more favourable to the expected metamorphofis. I was, however, miftaken. Thefe I examined with more attention than the reft; and the following account is of their proceedings alone. Like two ftrong and active wreftlers, they immediately rufhed together, and attacked each other on every fide: fometimes one would dive, leaving its adverfary at the furface of the water; one would defcribe a circular movement, while the other remained at reft in the centre; their motions at length became fo rapid as no longer to allow me to diftinguifh one from the other. Having quitted them for a fhort time, on my return I found them reunited as before, and amicably moving round the edge of the glafs by their common exertions."

Fig. 5. reprefents a fingular animal, which has a confiderable refemblance to a little lizard; its body is of a firm, gelatinous confiftence; its head is furnifhed on each fide with two fmall gelatinous horns, of which the two hindermoft are fituate the furtheft inward: its body is provided with four open fan-like paws, and fome appendages near the infertion of the tail, and terminates like that of a lizard: the ridge of the back is divided the whole way down by a band of a deep blue; the reft of the body, as well as the infide of its paws, is of a bright filvery white. It appears to be very fluggifh in its motions; and when difturbed by the finger, merely turned itfelf belly upwards, foon afterwards refuming its former pofition. Fig. 6. reprefents it reverfed. Martiniere caught it during a calm at the landing place on the Bafhee Iflands.

INSTITUTE is a name which has lately been fubftituted for *fchool* or *academy*. Formerly *inftitution*, in the propriety of the Englifh language, was fometimes ufed as a word of the fame import with *inftruction*; and now *inftitute* is employed, efpecially by the admirers of French innovations, to denote what had hitherto been called an academy. When royalty was abolifhed in France, it would have been abfurd to continue the titles *Royal* Academy of Sciences, *Royal* Academy of Infcriptions, &c; but inftead of merely abolifhing the word *royal*, and fubftituting *national* in its ftead, it occurred to the fertile brain of Condorcet, to abolifh the feven academies themfelves, or rather to melt them all down into one great academy; to which was given the appellation of the

Inftitute.

National INSTITUTE, or *New Academy of Arts and Sciences*. This academy, founded on a decree of the new conftitution, was opened on the 7th of December 1795, when BENEZECH, the then minifter for the home department, attended, and the decree of foundation was read; which was to the following purport:

"The Academy of Arts and Sciences belongs to the whole republic, and Paris is its place of refidence. Its employment is to aim at bringing all arts and fciences to the utmoft perfection of which they are capable. It is to notice every new attempt, and all new difcoveries, and to keep up a correfpondence with all foreign literary focieties. And by the particular orders of the Executive Directory, its firft ftudies are to be directed to thofe fubjects which more immediately tend to the reputation and advantage of the French republic."

The academy is to confift of 288 members, half of whom are to refide in Paris, the other half in the departments; and to them is to be added a certain number of foreigners, as honorary members, confined at prefent to twenty-four.

The academy is divided into three claffes, each clafs into fections, each fection to contain twelve members.

1ft clafs. Mathematics and natural philofophy. This clafs is divided into ten fections. 1. Mathematics. 2. Mechanical arts. 3. Aftronomy. 4. Experimental philofophy. 5. Chemiftry. 6 Natural hiftory. 7. Botany. 8. Anatomy and animal hiftory. 9. Medicine and furgery. 10. Animal œconomy, and the veterinary fcience.

2d clafs. Morality and politics. This clafs confifts of fix fections. 1. Analyfis of fenfations and ideas. 2. Morals. 3. Legiflature. 4. Political œconomy. 5. Hiftory. 6. Geography.

3d clafs. Literature and the fine arts. This clafs confifts of eight fections. 1. Univerfal grammar. 2. Ancient languages. 3. Poetry. 4. Antiquities 5 Painting. 6. Sculpture. 7. Architecture. 8. Mufic.

For each clafs a particular room in the Louvre is appropriated. No one can be a member of two claffes at the fame time, but a member of one clafs may be prefent at the meetings of any other Each clafs is to print, yearly, an account of its tranfactions.

Four times a-year there are to be public meetings. On thefe occafions, the three claffes meet together. At the end of each year, they are to give a circumftantial account to the legiflative body of the progrefs made in that year in the arts and fciences. The prizes given yearly by each clafs are to be publicly notified at certain times. The fums requifite for the fupport of the inftitution are to be decreed yearly by the legiflative body, upon a requifition made by the Executive Directory.

The firft forty-eight members were chofen by the Executive Directory, to whom the choice of the remaining members was confided. To the members, refidentiary in Paris, is referved the choice both of the depart-

Institute. ment and the foreign members. On a vacancy in any clafs, three candidates are named by the clafs for the choice of the body at large.

Each clafs is to have, at its place of meeting, lection of the products, both of nature and art, and a library, according to its particular wants.

The regulations of the inftitution, with refpect to the times of meeting, and its employments, are to be drawn up by the body at large, and laid before the legiflative affembly.

The hall in which the body at large holds its meetings, forms part of the weft wing of the Old Louvre, at prefent called the Mufeum. It formerly went by the appellation of the Hall of Antiques (*Salle des Antiques*); and as long as the kings inhabited this part of the palace, was occupied by their guards, from which circumftance it obtained the name of the Hall *des Cent Suiffes*. It was likewife appropriated to banquets and entertainments, given by the court on gala days; and it was to this place that Henry IV. was conveyed, on his affaffination by Ravaillac, in the *Rue de la Ferronnerie*.

It was built at the fame time with the reft of this part of the Louvre, about the year 1528, after the defign of Pierre Lefcot, abbot of Clugny. It is 144 feet in length, and [illegible] in breadth, and holds from [illegible] to [illegible] perfons. In order to adapt it to its new deftination, the floor has been funk, which gives a greater air of lightnefs to the roof. In the centre ftands a double table, in the form of a horfe-fhoe, supported by fphinxes, at which the members of the inftitute take their feats. This table is furrounded by two tiers of benches, which are raifed for the accommodation of fpectators, who have likewife feats provided for them in the vaft embrafures of the windows, and at each extremity of the hall.

Whether fcience will be advanced by the feven royal academies having been melted into one, time muft determine; but candour compels us to acknowledge, that the proceedings of the national inftitute have hitherto been abundantly interefting. Intimately connected with the national inftitute is the French fyftem of

National Instruction, which is likewife novel, and therefore fufficiently curious to deferve notice in a Work of this kind. When the Chriftian religion was abolifhed in France, it was impoffible to continue the univerfities and other feminaries which were founded by Chriftians, and obliged by their conftitution to teach, whether pure or not, the doctrines of Chriftianity. They were accordingly all fwept away, and a new fyftem of education planned, which was to be carried on in what they call

The Primary Schools.
The Central Schools.
The School of Health.
The School of Oriental Languages.
The Polytechnic School.
The National Inftitute.
The Jury of Public Inftruction.
The Commiffion of Public Inftruction.
The Legiflative Committee of Inftruction. And various other national eftablifhments for the improvement of particular fciences. Inftitute.

The firft degree of public inftruction is to be met with in the *Ecoles Primaires*, eftablifhed by a decree of the convention of the fecond *Pluviofe*, in the fecond year of the republic (A). Every diftrict is furnifhed with one of thefe fchools; the profeffors or mafters in which are paid from the national treafury; and to which every head of a family, without exception, is compelled by law to fend its children for inftruction. The fubjects taught in thefe primary or elementary fchools are divided into nine claffes:

1ft, Inftructions connected with the phyfical and moral fituation of children, prior to their entering into thefe fchools. *2d*. Similar inftructions as a guide to teachers in the national fchools. *3d*, The arts of reading and writing. *4th*, The elements of French grammar. *5th*, Elements of arithmetic and geometry, with the theory of the new menfuration. *6th*, The elements of geography. *7th*, Explanations of the principal phenomena and productions of nature. *8th*, Elements of agriculture. *9th*, Elements of republican morals.

Next to the primary fchools in rank and confequence are the *Ecoles Centrales*, which were eftablifhed by a decree of the Convention of the feventh *Ventofe* in the third year. They are fituated in the capital of every department, bearing the proportion of one central fchool to 300,000 inhabitants. In thefe fchools the republican youths are taught the fciences, and their application in real life. In each of them are profeffors for the following branches:

1. For mathematics. 2. Experimental philofophy and chemiftry. 3. Natural hiftory. 4. Agriculture and commerce. 5. Logic and metaphyfics. 6. Political economy and legiflation. 7. The philofophical hiftory of nations. 8. The art of healing. 9. Arts and manufactures. 10. Univerfal grammar. 11. The belles lettres. 12. The ancient languages. 13. The modern languages. 14. The fine arts.

Each central fchool is furnifhed with an extenfive public library—a botanic garden—a cabinet of natural hiftory—an apparatus for experimental philofophy—and a collection of machines and models connected with the arts and manufactures.

The profeffors of each fchool hold, every month, a public fitting, in which conferences are held relative to fubjects connected with the improvement of letters, the fciences, and the arts, which are the moft beneficial to fociety.

The object in the eftablifhment of the primary and central fchools was, the general inftruction of all claffes of the citizens; and it being incompatible with the perfect completion of that important purpofe, to expect from them the propagation of particular branches of fcience, it became neceffary to eftablifh other literary and fcientific academies.

Accordingly, the French government have founded, *1ft*, Schools of health (*les ecoles de fanté*), in Paris, Strafburgh, and

(A) We would tranflate this chronological jargon into the language of Chriftian Europe, were we not perfuaded that the French calendar, the French conftitution, and the French inftitutes, will have the fame duration: we truft in God not a long duration. For *Pluviofe*, and the other fantaftical names of months introduced into this article, fee Revolution, *Encycl.* n° 184.

Institute. and Montpelier, where medicine and surgery are studied; which schools are affirmed, by those who find nothing wrong in France, to be the most perfect of their kind, as well as new and unparalleled models for such institutions.

2*d*, Two schools for Oriental languages, in the national library, and in the college of France.

3*d*, The Polytechnic school in Paris, or central school for the direction of public works. This establishment is very generally admired and considered as a model for imitation. It contains more than 400 young persons, previously educated in the mathematics, and the majority of them intended for engineers in various lines; and they labour under the immediate direction of their tutors nine hours every day. It occupies the principal part of the *Palais de Bourbon* in Paris, and is furnished with a large collection of instruments and models. The journal of the Polytechnic school, which is published by the booksellers Regent and Bertrard at Paris, is a perfectly original work, and admirably calculated to convey useful information.

Of the national institute a sufficient account has been given in the preceding article. We proceed therefore to the jury of public instruction (*Le Jury Central d'Instruction*), of which the principal business is to superintend the primary and central schools. It appoints the professors in these schools, and examines into their conduct. Like the legislative body it is renewed by a third every half year. When they have chosen a professor for a central school, they submit their choice to the department; and, in case of disapprobation, they make another appointment. To this jury of public instruction the professors in the central schools are amenable for all misconduct connected with their offices; it may expel them, but all its decisions must be submitted for confirmation to the tribunal of the department.

There is also established at Paris a supreme council, called The Commission of Public Instruction, to which is entrusted the whole executive department. The preservation of the national monuments, of public libraries, museums, cabinets, and valuable collections; the superintendance of all the schools and the modes of instruction; all new inventions and scientific discoveries; the regulation of weights and measures; national statistics and political economy, are all placed under the authority of this supreme commission. For the commodious and regular execution of so many complicated branches of business, there is a large office, called *Le Secretariat*, which is divided into three departments.

1 For the regulation of the different kinds of instruction; of the modes of education in the schools; and for the choice of elementary books. 2. For weights and measures; inventions and discoveries; libraries and bibliography; museums, works of art, and literary rewards and encouragements. 3. For theatres, national feasts, republican institutions, and the erection of monuments.

As all public establishments require the superintendance and occasional correction of the legislature, in addition to that of their own immediate executive authority, it has been deemed necessary to appoint a permanent committee of instruction in the legislative body, to provide such sums as may be necessary for the preservation and improvement of this system of instruction. This legislative committee are invested with due authority for these purposes. Their objects are precisely the same as those of the commission of public instruction above described, only with this difference, that the latter superintends the execution of existing laws, whilst the former receives and improves them, or proposes new ones. This committee is divided into three departments, as is the commission, with exactly the same arrangement of their respective labours. The committee being charged with the erection of all new laws, its members, with a view to obtain accurately all the requisite information relative to the numerous branches of the arts, have procured from the legislative body the appointment of a *commission temporaire des arts* to be annexed to them, and to meet in the same house with them; which temporary commission is divided into sixteen classes: viz. 1. For Zoology; 2. Botany; 3. Mineralogy; 4. Physics; 5. Chemistry; 6. Anatomy; 7. Machinery; 8. Geography; 9. Artillery and Fortification; 10. Medals and Antiquities; 11. Bibliography; 12. Painting; 13. Architecture; 14. Sculpture; 15. Bridges and Causeways; and, 16. Musical Instruments.

The improvements of the national literary and scientific establishments are numerous and important.

1*st*, By a decree of the convention of the 11th *Prairial*, in the second year, it was enacted, that means should be adopted by which every possible advantage might be derived from the botanic gardens of the republic, in Turkey and other foreign countries. This politic decree clearly tended to render France, in the language of the reporter, *L'abregé de tous les climats, et l'entrepôt de l'Europe*. "The epitome of every climate, and the magazine of Europe." Those plants which thrive between the tropics may be cultivated in the south of France; and those which are the produce of northern climates, may be cultivated in the northern departments; by which means, France will be in possession of all foreign plants and drugs, without the exportation of specie.

2*d*, The National Bibliography was decreed in the sitting of 22d *Germinal*, in the second year. It consists of a complete catalogue of books of all descriptions, the property of the nation; it was then ascertained, that the republic possessed more than ten millions of books. The titles of them were to be adjusted by actual comparisons; the manuscripts to be registered separately; anonymous productions were to be arranged according to their subjects; and those of known authors in the alphabetical order of the names. The several editions to be classed according to their dates: and what may be deemed more important, this French National Bibliography will contain a dictionary of anonymous books, as well as those published under fictitious names, a desideratum in the republic of letters.

3*d*, The annihilation of all *patois*, or dialects, decreed in the sitting of the 16th *Prairial*, in the second year. Notwithstanding the universality of the French language, and that it was exclusively spoken in the majority of the inland departments, yet there existed thirty various dialects in France. It is more astonishing that Rozier had remarked, that between one neighbouring village and another, there was so considerable a difference in the dialect, that the inhabitants could not understand each other; and the vinestock had thirty different names. The naturalist, Villars, has stated, that in the nomenclature of vegetables, in the departments, he had only met with an hundred which had a common appellation.

4th. The establishment of the *Conservatoire des Arts et Metiers*, was decreed in the sitting of the 8th of *Vendemiaire*, in the third year. This consists of a spacious hall, in the form of an amphitheatre, and contains the instruments and the models of machinery connected with the arts, and a description of their uses, with every book relating to them. Annexed to this establishment are three expositors and a draughtsman, who explain to the students the use of each instrument, and who register every new discovery, which is presented to the *Bureau de Consultation*, to the lyceum of arts, the *ci-devant* academy of sciences, or to the board of commerce.

5th, The establishment of the board of longitude was decreed in the sitting of the 7th of *Messidor*, third year. It was certainly a disgrace under the monarchy, that an astronomical and nautical establishment, which had already proved so beneficial to Great Britain, should not have been adopted in France. In consequence of this decree, the French board is now as complete as the English. It consists of ten members, and has under its jurisdiction the national observatory at Paris, and all the astronomical instruments belonging to the republic. It corresponds with foreign astronomers; delivers public lectures on astronomy and navigation; and its proceedings are annually recited in a public sitting.

6th, The general school of the Oriental languages was established by a decree of the 10th of *Germinal*, in the fourth year. This school adjoins to the national library, and all the books and manuscripts relative to Oriental literature are deposited in it.

7th, The national museum of antiquities was decreed in the sitting of 20th of *Prairial*, fourth year. A school of this description was successfully established at Vienna, by Eckel; at Gottingen, by Heyne; at Leipsick, by Ernest; and even at Strasburgh, by the celebrated Oberlin: Paris was, however, without one. This national archeology, or science of antiquity, is divided into nine different classes: inscriptions, characters, statues, *bas reliefs*, sculptures, paintings, mosaics, medals, civil, religious, and military instruments. This extensive establishment is under the direction of two principal professors; *le Conservateur Professeur, et le Conservateur Bibliothécaire*. The province of the former is to deliver public lectures on the several branches of antiquities, to teach the theory of medals and engravings, the history of the arts among the ancients, &c. The duties of the latter are merely of a bibliographical nature.

8th, The new modelling of the Grand National Library, was decreed in the sitting of 25th *Vendemiaire*, in the fourth year. By virtue of this decree, the place of librarian in chief was suppressed, and the whole establishment placed under a *conservatoire* of eight members; of whom two were appointed for the superintendence of printed books; two for manuscripts; two for antiquities; and two for engravings. From these a temporary director is annually chosen, who superintends the whole acts occasionally as president of this assembly, and maintains a regular correspondence with the constituted authorities relative to the concerns of the library.

9th, The augmentation of the Museum of Natural History, formerly called *Le Jardin Royal des Plantes*. This establishment was decreed the 15th *Brumaire*, third year, upon a report of Thibadeau, in the name of the committee of Public Instruction. Besides the addition of [illegible] and various other buildings, there are new collections of natural curiosities and productions; and the library is much increased. It is open to the public three times a week. At stated periods all the naturalists in Paris deliver courses of lectures in the various branches of natural history. The museum is said to have received greater improvements from this augmentation than from all the labours of Buffon, or from its foundation, since the time of Tournefort. Institute.

10th, The *Ecole des Mines* was established in the *Hotel des Monnaies*, and has for its direction the naturalist Le Sage. This institution is unrivalled in Europe; and the collection of mineralogical curiosities surpasses whatever can be conceived.

11th, The society of natural history in Paris, deservedly classes among those which have rendered the greatest services to the cause of science since the revolution. A lecture of public instruction is held every ten days, which is generally given by one of the members, and which is open to all the lovers of natural history. Premiums are proposed for dissertations; one of which, by the late C. Herman, jun. (whose early decease was a great loss to the republic of letters) on the *apterous* class of insects, may be said to constitute an epocha in the annals of natural history. The society has published a volume of memoirs, in folio, entitled, "*Transactions of the Society of Natural History.*" It has likewise erected a statue to the great Linnæus, in the national garden of plants; and, at the period when every public instruction was suspended, gave lectures on the different branches of science belonging to its department. Several intelligent and skilful navigators, among others those sent in search of the unfortunate La Peroufe, as well as those which accompanied Buonaparte on his romantic expedition to Egypt, were members of this society.

This statement of facts relative to the present state of public instruction, the sciences, the arts, and the progress of national literature in France, has been taken from a miscellany, of which the principal writers are well acquainted with what is doing in that distracted country. They call it a sublime system; and seem to consider the increase of the national library, the improvement of the botanic gardens, and the discoveries that have been made by the different schools or institutes, as furnishing a demonstration that the republican government is more favourable to the advancement of science, than the monarchical, whether absolute or limited. But it should not be forgotten, that this system is yet in its infancy; and that in prosecuting new schemes, all men, and more especially Frenchmen, are actuated by an enthusiasm which gradually cools as their pursuits become familiar. We shall therefore venture to predict, that the different schools will not display such ardour seven years hence as they do at present; and that if the republican government continue a dozen of years in France, the progress of science in that country will not be more rapid than it was under the monarchy. We must remember, too, that the French libraries, museums, and picture galleries, have been improved by means which the morals of other governments do not employ—by rapine and robbery.

That something may be learned from this system to

 improve

Inſtitute, Inſurance. improve the modes of education in other countries, we admit; and it is for that reaſon that we have inſerted an account of it. But if it contains ſomething worthy of imitation, it contains likewiſe much to be ſhunned. We do not think it conſiſtent with the *rights of man* to *compel* parents to ſend their children to be educated in *particular* ſchools; eſpecially in ſchools where not only religious inſtruction is omitted, but where, there is reaſon to believe, that the profeſſors are at pains to raze all religious impreſſions from the youthful mind. In a nation denying the truth of Chriſtianity, it is not to be ſuppoſed that the Chriſtian religion will be publicly taught; but in a nation of philoſophers, as the French call themſelves, it might have been expected that the laws of religious toleration would have been ſo far regarded, that Chriſtian parents would not have been *compelled* to ſend their children to *antichriſtian* ſchools! But it is not Chriſtianity alone that is neglected in this *ſublime* ſyſtem of education. Though the legiſlative body has ſome time ago decreed that there is a God, there is not in any one of thoſe ſchools the ſmalleſt care taken to inſtruct the republican youth in the principles even of natural religion! We might indeed have looked for it under the title *Metaphyſics*, had not the conſtitution of the National Inſtitute taught us, that French metaphyſics attend to nothing but the analyſis of ſenſations and ideas. Yet the legiſlators might have liſtened on this ſubject to a republican as ſound as themſelves, and who was likewiſe no friend to ſuperſtition. "Nam et Majorum inſtituta tueri ſacris, ceremoniiſque retinendis ſapientis eſt. Non ſolum ad religionem pertinet, ſed etiam ad *civitatis* ſtatum, ut ſine iis, qui ſacris publice præſunt, religioni privatæ ſatisfacere non poſſint." *Cicero de Nat. Deorum.*

INSURANCE, in law and commerce, though an excellent inſtitution, is not of high antiquity. The oldeſt laws and regulations concerning inſurance, with which the indefatigable Beckmann is acquainted, are the following:

On the 28th of January 1523, five perſons appointed for that purpoſe drew up at Florence ſome articles which are ſtill employed on the exchange at Leghorn. Theſe important regulations, together with the preſcribed form of policies, which may be conſidered as the oldeſt, have been inſerted, in Italian and German, by Magens, in his Treatiſe on Inſurance, average, and bottomry, publiſhed at Hamburgh in 1753.

There is ſtill preſerved a ſhort regulation of the 25th May 1537, by the Emperor Charles V. reſpecting bills of exchange and inſurance, in which the ſtrictly fulfilling only of an agreement of inſurance is commanded.

In the year 1556, Philip II. king of Spain, gave to the Spaniſh merchants certain regulations reſpecting inſurance, which are inſerted by Magens, with a German tranſlation, in his work before mentioned. They contain ſome forms of policies on ſhips going to the Indies.

In the year 1598, the *Kamer van aſſurantie*, chamber of inſurance, was eſtabliſhed at Amſterdam. An account of the firſt regulations of this inſurance office may be ſeen in Pontanus's Hiſtory of the city of Amſterdam, and in other works.

In the year 1600, regulations reſpecting inſurance were formed by the city of Middelburg in Zealand.

It appears that the firſt regulations reſpecting inſurances in England, which may be ſeen in *Anderſon's Hiſtory of Commerce*, were made in the year 1601. We find by them, that inſurers had before that period conducted themſelves in ſuch a manner, that the utmoſt confidence was repoſed in their honeſty, and that on this account few or no diſputes had ariſen. Inſurance.

Of the various policies for inſurance in England, a pretty accurate account will be found in the *Encyclopædia*; but there is one of them, of which our account muſt be acknowledged to be now defective. This is,

INSURANCE on lives; which is a policy that has greatly increaſed, in conſequence of its utility being more generally underſtood. Of the two offices for life-aſſurances, noticed in that article, the former, entitled the *Amicable Society*, has extended the number of its ſhares to 4000; but, as we have already obſerved, the nature of the inſtitution is too limited to become of general importance. The latter, entitled, the *Society for Equitable Aſſurances on Lives and Survivorſhip*, is undoubtedly one of the moſt important inſtitutions of the kind, as will appear by the following account, with which we have been favoured by an obliging correſpondent, and upon the accuracy of which our readers may depend:

The members of the equitable ſociety, finding, in June 1777, that their affairs were in a flouriſhing ſituation, reſolved to reduce their annual premiums one tenth; and in 1782, adopted new tables agreeable to the probabilities of life at Northampton, in lieu of thoſe they had hitherto uſed, formed from the London bills of mortality. But though it was evident, that the new tables were much better adapted for aſſuring promiſcuouſly perſons reſiding in the country, or in large towns, it was thought proper, for greater ſecurity, to make an addition of 15 per cent. to the real value of the aſſurances, as computed from the table of mortality at Northampton; and with the view of making an adequate compenſation to the aſſured for their former payments, which had been ſo much higher than would be required by the new rates, an addition was made to their claims of L.1 : 10s. per cent. for every premium they had paid. The conſequence of theſe meaſures proved highly favourable to the ſociety; for its buſineſs increaſed ſo faſt, that in 1785 it was nearly doubled; the ſums aſſured amounting to upwards of L.720,000. At this period, the favourable reſult of a minute and very laborious inveſtigation of the ſtate of the ſociety, induced them to take off the 15 per cent. charged upon the premiums in 1782, and make a further addition to the claims of L.1 per cent. for every payment made prior to the 1ſt January 1780. A ſtill greater increaſe of ſucceſsful buſineſs determined them, in 1791, to make another addition of L.1 per cent. to the claims; and in the following year, a further addition of L.2 per cent.; by which the claims upon aſſurances of the year 1770 were more than doubled; and thoſe of an earlier date increaſed in a ſtill higher proportion. By theſe advantages to its members, and the honourable and truly equitable manner in which the concerns of the ſociety are tranſacted, the augmentation of their buſineſs has been ſo great, that on the 31ſt December 1792, the ſums aſſured (without including the additions made to them) amounted to upwards of L.3,000,000; and on the 31ſt December 1795, to about L.4,000,000.

The

Insurance. The rates of assurance, as reduced to their real values in 1786, and according to which the society now transact business, are as follows:

Sum Assured £. 100.

Age.	*One Year.*			*Seven Years.*			*Whole Life.*		
15	£. 0	17	11	£. 1	2	11	£. 1	18	7
20	1	7	3	1	9	5	2	3	7
25	1	10	7	1	12	1	2	8	1
30	1	13	3	1	14	11	2	13	4
35	1	16	4	1	18	10	2	19	10
40	2	0	8	2	4	1	3	7	11
45	2	6	8	2	10	10	3	17	11
50	2	15	1	3	0	8	4	10	10
55	3	5	0	3	12	0	5	6	4
60	3	18	1	4	7	1	6	7	4
65	4	15	2	5	10	10	7	16	9

The other offices in London for the assurance of lives are, the *Royal Exchange Assurance*, the *Westminster Society*, and the *Pelican Life Office*

The corporation of the *Royal Exchange Assurance* was empowered to assure lives by its second charter, dated 29th April 1721; but the original object of the company being sea assurances, and the true principles of assuring on lives being at that time little understood, this branch of their business was at first comparatively small: they generally required a premium of five or six guineas per cent. without any regard to the age; and the assurance, which was usually for a small sum, was seldom for a greater term than one year. In this manner they continued to assure upon lives till the end of the year 1783, when the increasing importance of this part of their business, which they had some years felt, induced them to adopt a regular table of rates of assurance, according to the Northampton registers of mortality, but with a greater addition to the real values than had been made by the "Society for Equitable Assurances on Lives and Survivorship." This was thought proper, from the consideration that the assurers with the Royal Exchange company are not in any case liable to a call upon them beyond the premium they engage to pay, and have the security of the capital and funds of the company arising from the other branches of their business; however, the company, finding themselves successful in their life assurances, determined, in 1790, to reduce their premiums; and in 1797 made a still greater reduction, by which they are brought very near to those above stated. This company have agents in all the principal towns of Great Britain, and are impowered to assure lives in all parts of the world.

The *Westminster Society* was established in 1792, for assuring lives, and granting annuities. Their terms are nearly the same as those of the Royal Exchange Assurance; but not being a corporate body, every person assuring signs a declaration, that he accepts the joint stock of the society as his security.

The *Pelican Life Office* was instituted in 1797, by some of the principal proprietors of the Phœnix Fire Office. The rates which they have published vary considerably from those of the other offices; but whether they are founded on more just principles, time and experience must determine. This society also makes a new species of assurance, by way of endowment for daughters, or for children generally, when they shall attain the age of twenty-one years.

Integral, Interest. INTEGRAL CALCULUS, in the new analysis, is the reverse of the differential calculus, and is the finding of the integral from a given differential; being similar to the inverse method of fluxions, or the finding the fluent to a given fluxion. See FLUXIONS, *Encycl.*

INTEREST, is the allowance given for the use of money by the borrower to the lender, and is either *simple* or *compound*. The method of computing both interests is explained in the article ALGEBRA, (*Encycl.*) page 427, &c.; and the subject of simple interest is again resumed in ARITHMETIC, (*Encycl.*) n° 20. The application of the canons for the computation of compound interest, to the value of annuities, the only case in which that interest is allowed by the laws of this country, may be seen in the articles ANNUITY and SURVIVORSHIP, (*Encycl.*); where various tables are given to facilitate the different computations. Some of our readers, however, have expressed a wish to have the rule for computing compound interest so stated, as to be understood by those who are unacquainted with algebraic symbols. Their wish may be easily gratified.

The general formula $S = pR^t$ answers for the amount of any sum, whether the interest be payable yearly, half-yearly, quarterly, or daily. Let R denote the amount of one pound for the first payment, and t the number of payments, the unit being from the commencement till the first payment is due; also, let l denote the logarithm of any quantity before which it is wrote; then, from the known property of logarithms, the theorem may be expressed thus, $l.\,S = l.\,p + l.\,R \times t$.

Required the amount of L. 250 at 5 per cent. compound interest, for 12 years, reckoning the interest payable yearly, half-yearly, quarterly, and daily?

Yearly, $p = 250$, $R = 1{\cdot}05$, $t = 12$.

$$0{\cdot}0211893 = l.\,R$$
$$12$$

$$\cdot 2542716 = l.\,R \times t.$$
$$2{\cdot}3979400 = l.\,p.$$

$$l.\,S = 2{\cdot}6522116 \text{ — L. } 448:19:3\tfrac{1}{4} = \text{Amount.}$$
$$250$$

$$198:19:3\tfrac{1}{4} = \text{Comp. interest.}$$

Half yearly, $p = 250$, $R = 1{\cdot}025$, $t = 24$.

$$0{\cdot}0107239 = l.\,R.$$
$$24$$

$$428956$$
$$214478$$

$$\cdot 2573736 = l.\,R \times t.$$
$$2{\cdot}3979400 = l.\,p.$$

$$l.\,S = 2{\cdot}6553136 \text{ — L. } 452:3:7\tfrac{1}{4} = \text{Amount.}$$
$$250$$

$$202:3:7\tfrac{1}{4} = \text{Interest.}$$

Quarterly.

Quarterly. $p = 250$, $R = 1\cdot0125$, $t::48$.

$$0\cdot0053950 = l.\ R.$$
$$48$$
$$431600$$
$$215800$$
$$\cdot2589600 = l.\ R \times t.$$
$$2\cdot3979400 = l.\ p.$$

$$l.\ S = 2\cdot6569000 — L.453:16:8\tfrac{1}{2} = \text{Amount.}$$
$$250$$
$$203:16:8\tfrac{1}{2} = \text{Intereft.}$$

Daily, $p = 250$, $R = 1 + \frac{\cdot05}{365} = \frac{365\cdot05}{365}$, $t = 365 \times 12$.

$$2\cdot5623524$$
$$2\cdot5622929$$
$$\cdot0000595 = l.\ R.$$
$$4380$$
$$47600$$
$$1785$$
$$2380$$
$$\cdot2606100 = l.\ R \times t.$$
$$2\cdot3979400 = l.\ p.$$

$$l.\ S = 2\cdot6585500 — L.455:11:3\tfrac{1}{2} = \text{Amount.}$$
$$250$$
$$205:11:3\tfrac{1}{2} = \text{Intereft.}$$

INTERPOLATION, in the modern algebra, is ufed for finding an intermediate term of a feries, its place in the feries being given. See ALGEBRA and SERIES, *Encycl.*

The method of interpolation was firft invented by Mr Briggs, and applied by him to the calculation of logarithms, &c. in his Arithmetica Logarithmica, and his Trigonometria Britannica; where he explains, and fully applies, the method of interpolation by differences. His principles were followed by Reginal and Mouton in France, and by Cotes and others in England. Wallis made ufe of the method of interpolation in various parts of his works; as his arithmetic of infinites, and his algebra, for quadratures, &c. The fame was alfo happily applied by Newton in various ways: by it he inveftigated his binomial theorem, and quadratures of the circle, ellipfe, and hyperbola. See Wallis's Algebra, chap. 85. &c. Newton alfo, in lemma 5. lib. 3. Princip. gave a moft elegant folution of the problem for drawing a curve line through the extremities of any number of given ordinates; and in the fubfequent propofition, applied the folution of this problem to that of finding, from certain obferved places of a comet, its place at any given intermediate time. And Dr Waring, who adds. that a folution ftill more elegant, on fome accounts, has been fince difcovered by Meff. Nichol and Stirling, has alfo refolved the fame problem, and rendered it more general, without having recourfe to finding the fucceffive differences. *Philof. Tranf.* vol. 69. part 1. art. 7.

INTERSCENDENT, in algebra, is applied to quantities, when the exponents of their powers are radical quantities. Thus $x^{\sqrt{2}}$, $x^{\sqrt{a}}$ &c. are interfcendent quantities.

Interfcendent || Involution.

INTERSTELLAR, a word ufed by fome authors to exprefs thofe parts of the univerfe that are without and beyond the limits of our folar fyftem.

INTRADOS, the interior and lower fide, or curve, of the arch of a bridge, &c. In contradiftinction from the extrados, or exterior curve, or line on the upper fide of the arch. See ARCH in this *Suppl.*

INVOLUTION and EVOLUTION, are terms introduced into geometry by the celebrated Mr Huyghens, to exprefs a particular manner of defcribing curvilineal fpaces which occurred to him when occupied in the improvement of his noble invention of pendulum clocks. Although he was even aftonifhed at the accuracy of their motion, and they foon fuperfeded all balance clocks, he knew that the wide vibrations were fomewhat flower than the narrow ones, and that a circle was not fufficiently incurvated at the fides to render all the vibrations ifochronous. The proper curve for this purpofe became an interefting object. By a moft accurate inveftigation of the motions of heavy bodies in curved paths, he difcovered that the cycloid was the line required. Lord Brouncker had difcovered the fame thing, as alfo Dr Wallis. But we do not imagine that Huyghens knew of this; at any rate, he has the full claim to the difcovery of the way of making a pendulum ofcillate in a cycloidal arch. It eafily occurred to him, that if the thread by which the pendulum hangs be fufpended between two curved cheeks, it would alternately lap on each of them in its vibrations, and would thus be raifed out of the circle which it defcribes when fufpended from a point. But the difficulty was to find the proper form of thofe cheeks. Mr Huyghens was a moft excellent geometer, and was poffeffed of methods unknown to others, by which he got over almoft every difficulty. In the prefent cafe there was fortunately no difficulty, the means of folution offering themfelves almoft without thought. He almoft immediately difcovered that the curve in queftion was the fame cycloid. That is, he found, that while a thread unwinds from an arch of a cycloid, beginning at the vertex, its extremity defcribes the complementary arch of an equal cycloid.

Thus he added to this curve, already fo remarkable for its geometrical properties, another no lefs curious, and infinitely exceeding all the others in importance.

The fteps by which this property was difcovered are fuch direct emanations from general principles, that they immediately excited the mind of Mr Huyghens, which delighted in geometry, to profecute this method of defcribing or transforming curve lines by evolution. It is furprifing that it had not ere this time occurred to the ancient geometers of the laft century, and particularly to Dr Barrow, who feems to have racked his fancy for almoft every kind of motion by which curve lines can be generated. Evolution of a thread from a curve is a much more obvious and conceivable genefis than that of the cycloid invented by Merfennus, or that of the conchoid by Nicomedes, or thofe of the conic fections by Vieta. But except fome vague expreffions by Ptolemy and Gaffendus, about defcribing fpirals by

Involution. by a thread unlapped from a cylinder, we do not recollect any thing of the kind among the writings of the mathematicians; and it is to Huyghens alone that we are indebted for this very beautiful and important branch of geometry. It well deserves both of these epithets. The theorems which constitute the doctrines of evolution are remarkable for their perspicuity and neatness. Nothing has so much contributed to give us clear notions of a very delicate subject of mathematical discussion, namely curvature, and the measure and variations of curvature. It had become the subject of very keen debate; and the notions entertained of it were by no means distinct. But nothing can give such a precise conception of the difference of curvature, in the different parts of a cycloid or other curve, as the beholding its description by a radius continually varying in length. This doctrine is peculiarly valuable to the speculator in the higher mechanics. The intensity of a deflecting force is estimated by the curvature which it induces on any rectilineal motion; and the variations of this intensity, which is the characteristic of the force, or what we call its nature, is inferred from the variations of this curvature. The evolution and involution of curve lines have therefore great claim to our attention. But a Work like ours can only propose to exhibit an outline of the subject; and we must refer our readers to those eminent authors who have treated it in detail. Varignon, in the Memoirs of the French Academy for 1726, has been at immense pains to present it in every form; James Bernoulli has also treated the subject in a very general and systematic manner. Some account is given of it in every treatise of fluxions. We recommend the original work of Mr Huyghens in particular; and do not hesitate to say, that it is the finest specimen (of its extent) of physico-mathematical discussion that ever has appeared. Huyghens was the most elegant of all modern geometers; and both in the geometrical and physical part of this work, *De Horologio Oscillatorio*, he has preserved the utmost rigour of demonstration, without taking one step in which Euclid or Apollonius would not have followed him.

——————— *juvat integros accedere fontes*
Atque haurire.

Such authors form the taste of the young mathematician, and help to preserve him from the almost mechanical procedure of the expert symbolical analyst, who arrives at his conclusion without knowing how he gets thither, or having any notions at all of the magnitudes of which he is treating.

There are two principal problems in this doctrine.

I. To ascertain the nature of the figure generated by the evolution of a given curve.

II. To determine the nature of the curve by whose evolution a given curve may be generated.—We shall consider each of these in order, and then take the opportunity which this subject gives of explaining a little the abstruse nature of curvature, and its measures and variations, and take notice of the opinions of mathematicians about the precise nature of the angle of contact.

Plate XXXI. The curve line ABCDEF (fig. 1.) may be considered as the edge of a crooked ruler or mould; a thread may be supposed attached to it at F, and then lapped along it from F to A. If the thread be now led away from A, keeping it always tight, it is plain that the extremity A must describe a curve line A*bcdef*, and that the detached parts of the thread will always be tangents to the curve ABCDEF. In like manner will the curve line F*d'c'b* A' be described by keeping the thread fast at A, and unlapping it from the other end of the mould

This process was called by Mr Huyghens the Evolution of the curve ADF. ADF is called the Evolute. A*df* was named by him the Curve by Evolution. It has been since more briefly termed the Evolutrix, or unlapper. It has also been called the Involute; because, by performing the process in the opposite direction *fd*A, the thread is lapped up on the mould, and the whole space ADF*fd*A is folded up like a fan. The detached parts C*c*, D*d*, or C*c'*, D*d'*, &c. of the thread, are called Radii of the Evolute; perhaps with some impropriety, because they rather resemble the momentary radii of the evolutrix. We may name them the evolved radii. The beginning A of evolution may be considered as the vertex of the curves, and the ends F and *f* may be called the terms.

There is another way in which this description of curve lines may be conceived. Instead of a thread F*f* gradually lapped up on the mould, we may conceive F*f* to be a straight edged ruler applied to the mould, and gradually rolled along it without sliding, so as to touch it in succession in all its points. It is evident, that by this process the point *f* will describe the curve *fd*A, while the point F describes the other curve F*da'*. This way of conceiving it gives a great extension to the doctrine, and homologates it with that genesis of curve lines by which cycloids of all kinds are described, and which we may distinguish by the name of Provolution. For it is plain, that the relative motions of the points A and *b* are the same, whether the ruler *b*B*b'* roll on the mould ABF, or the mould roll on the ruler: but there will be a great difference in the form of the line traced by the describing point, if we suppose the plane on which it is traced to be attached to the rolling figure. Thus, when a circle rolls on a straight line, a point in its circumference traces a cycloid on the plane attached to the straight line, while the point of the straight line which quitted the circle describes on the plane attached to the circle another line; namely, the involute of the circle. This mode of description allows us to employ a curved ruler in place of the straight one *b*B*b'*; and thus gives a vast extension to the theory. But at present we shall confine ourselves to the employment of the straight line *b*B*b'*, only keeping in mind, that there is an intimate connection between the lines of evolution and of provolution.

By the description now given of this process of evolution and involution, it is plain,

1. That the evolution is always made from the convex side of the evolute.

2. That the evolved radii B*b*, C*c*, D*d*, &c. are respectively equal to the arches BA, CA, DA, &c. of the evolute which they have quitted; and that *b*B*b'*, *c*C*c'*, *d*D*d'*, &c. are always equal to the whole arch ADF.

3. That any point B of the lapped up thread describes during its evolution a curve line B*γδεφ* parallel to *bcdef*; because these curves are always equidistant from each other.

4. That if the thread extend beyond the mould as a tangent to it, the extremity *a* will describe a parallel or equidistant

equidiſtant curve *α β γ δ ε ϕ*, lying without A *b c d e f*. From this it appears that B *γ δ ε ϕ* is the complete evolutrix of FEDCB, while *b d c e f* is the evolutrix of that arch, and the added tangent B *b*. In like manner, the lapped up thread ADF, with the added part F*ϕ*, deſcribes the evolutrix *ϕ* *δ*′ *β*′ *γ*′ *α*′ A′.

5. If from any point C of the evolute there be drawn lines C *b*, C *c*, C *d*, C *e*, &c. to the evolutrix, thoſe which are more remote from the vertex are greater than thoſe which are nearer. Draw B *b*, *c* C, *d* D, *e* E, touching the evolute. C *b* is leſs than CB + B *b*; that is (2), than C *c*. Again, DC + C *c* is equal to D *d*, which is leſs than DC + C *d*. Therefore C *c* is leſs than C *d*. Now let C *e* cut D *d* in *r*. Then *e r* + *r* DE is greater than *e* E. But *e* E is equal to *d r* + *r* DE. Therefore *e r* is greater than *d r*; and *e r* + *r* C is greater than *d r* + *r* C, which is greater than *d* C. Therefore *e* C is greater than *c* C.

6. Hence it follows, that a circle deſcribed round any point of the evolute, with a radius reaching to any point of the evolutrix, will cut the evolutrix in that point, and be wholly within it on the ſide remote from the vertex, and without it on the ſide next the vertex.

7. The evolved radius cuts every arch of the evolutrix perpendicularly, or a right line drawn through the interſection at right angles touches the evolutrix in that point. Through any point *d* draw the line *m d t* at right angles to *d* D. The part of it *m d* next to the vertex is wholly without the curve, becauſe it is without the circle deſcribed round the centre D; and this circle is without the evolutrix on that ſide of *d* which is next the vertex (6). Any point *t* on the other ſide of *d* is alſo without the curve. For let *t e* E be another evolved radius, cutting D *d* in *n*: then *n d* is leſs than *n t*, becauſe *n d t* is a right angle by conſtruction; and therefore *n t d* is acute. But becauſe E *n* + *n* D are greater than ED, E *n* + *n d* are greater than ED + D*d*, that is, than E*e*, and *n d* is greater than *ne*. Therefore, ſince it is leſs than *n t*, it follows that *n e* is much leſs than *n t*, and *t* lies without the curve. Therefore the whole line *m d t* is without the curve, except in the point *d*. It therefore touches the curve in *d*, and the radius D *d* cuts it at right angles in that point. By the ſame reaſoning, it is demonſtrated, that all the curves A *b d f*, *α β δ ϕ*, A′ *b*′ *d*′ *f*′, *α*′ *β*′ *δ*′ *ϕ*′, are cut perpendicularly by the tangents to the evolute. Alſo all theſe curves interſect the evolute at right angles in their vertexes

It follows from this propoſition, that from every point, ſuch as *s*, or *i*, or *o*, &c. in the ſpace AOF comprehended by the evolute and its extreme tangents AO, FO, two perpendiculars may be drawn to the evolutrix A *d f*; and that from any point in the ſpace within the angle A *o f* only one perpendicular can be drawn; and that no perpendicular can be drawn from any point on the other ſide of ADF. Apollonius had obſerved theſe circumſtances in the conic ſections, but had not thought of marking the boundary formed by the evolute ADF. Had he noticed this, he would certainly have diſcovered the whole theory of evolution, and its importance in ſpeculative geometry.

It alſo follows from this propoſition, that if a curve A *b c d e f* is cut by the tangents of ABCDEF at right angles in every point, it will be deſcribed by the evolution of that curve: For if the evolutrix, whoſe vertex is A, be really deſcribed, it will coincide with A *b c d* in A, and have the ſame tangent; it therefore does not deviate from it, otherwiſe their tangents would ſeparate, and would not both be at right angles with the lines touching the evolute. They muſt therefore coincide throughout.

8. The arches *b c d* and *β γ δ*, intercepted by the ſame radii B *b* and D *d*, may be called *concentric*; and the angles contained between the tangents drawn thro' their extremities are equal. Thus the angle *λ π ν* is equal to *l p o*: but although equidiſtant, parallel, and containing the ſame angle between their tangents and between their radii, they are not ſimilar. Thus, the arch *α β* has a curvature at *α* that is the ſame with that of any circle whoſe radius is equal to A *α*; but the curvature at A is incomparable with it, and unmeaſurable. The ſame may be ſaid of the curvatures at *β* and at B.

9. If a circle *u d z* be deſcribed round the centre D with the radius D *d*, it both touches and cuts the evolutrix in the point *d*, and no circle can be deſcribed touching the curve in that point, and paſſing between it and the circle *u d z*: For ſince it touches the curve in *d*, its centre muſt be ſomewhere in the line *d* D perpendicular to *m d t*. It cannot be in any point *n* more remote from *d* than D is; for it would paſs without the arch *d u*, and be more remote than *d u* from the arch *d* of the evolutrix. On the other ſide, it would indeed paſs without the arch *d z*, which lies within the arch *d e* of the evolutrix: but it would alſo paſs without the curve. For it has been already demonſtrated (7) that *n d* is greater than *n e*; and the curve would lie between it and the circle *d z*.

Thus it appears, that a circle deſcribed with the evolved radius approaches nearer to the curve, or touches it more cloſely, than any other circle; all other circles either interſect it in meaſurable angles, or are within or without the curve on both ſides of the point of contact. This circle *u d z* has therefore the ſame curvature with the curve in the point of contact and coaleſcence. It is the EQUICURVE CIRCLE, the circle of equal curvature, the OSCULATING CIRCLE (a name given it by Leibnitz). The evolved radius of the evolute is the RADIUS OF CURVATURE of the evolutrix, and the point of the evolute is the CENTRE OF CURVATURE at the point of contact with the evolutrix. The evolute is the geometrical locus of all the centres of curvature of the evolutrix.

This is the moſt important circumſtance of the whole doctrine of the involution and evolution of curve lines. It is aſſumed as a ſelf evident truth by the precipitant writers of elements. It is indeed very like truth: For the extremity of the thread is a momentary radius during the proceſs of evolution; and any minute arch of the evolute nearer the vertex muſt be conceived as more incurvated than the arch at the point of contact, becauſe deſcribed with ſhorter radii: for the ſame reaſon, all beyond the contact muſt be leſs incurvated, by reaſon of the greater radii. The curvature at the contact muſt be neither greater nor leſs than that of the circle. But we thought it better to follow the example of Huyghens, and to eſtabliſh this leading propoſition on the ſtricteſt geometrical reaſoning, acknowledging the ſingular obligation which mathematicians are under to him for giving them ſo palpable a method of fixing their notions on this ſubject When the evolute of a curve is given, we have not only a clear view of the geneſis of the

the curve, with a neat and accurate mechanical method of deſcribing it, but alſo a diſtinct comprehenſion of the whole curvature, and a connected view of its gradual variations.

We ſpeak of curvature that is greater and leſſer; and every perſon has a general knowledge or conception of the difference, and will ſay, that an ellipſis is more curved at the extremities of the tranſverſe axis than any where elſe. But before we can inſtitute a compariſon between them with a preciſion that leads to any thing, we muſt agree about a meaſure of curvature, and ſay what it is we mean by a double or a triple curvature. Now there are two ways in which we may conſider curvature, or a want of rectitude: We may call that curvature which, [illegible] en ſpace, carries us twice as far from the ſtraight line; or we may call that a double curvature by which we deviate twice as much from the ſame direction. Both of theſe meaſures have been adopted; and if we would rigidly adhere to them, there would be no room for complaint: but mathematicians have not been ſteady in this reſpect, and by mixing and confounding theſe meaſures, have frequently puzzled their readers. All agree, however, in their firſt and ſimple meaſures of curvature, and ſay, that the curvature of an arch of a circle is as the arch directly, and as the radius inverſely. This is plainly meaſuring curvature by the deflection from the firſt direction. In an arch of an inch long, there is twice as much deflection from the firſt direction when the radius of the circle is of half the length. If the radius is about $57\frac{1}{4}$th inches, an arch of one inch in length produces a final direction one degree different from the firſt. If the radius is $114\frac{1}{2}$ inches, the deviation is but half of a degree. The linear deflection from the ſtraight path is alſo one half. In the caſe of circles, therefore, both meaſures agree: but in by far the greateſt number of caſes they may differ exceedingly, and the change of direction may be greateſt when the linear deviation is leaſt. Flexure, or change of direction, is, in general, the moſt ſenſible and the moſt important character of curvature and is underſtood to be its criterion in all caſes. But our proceſſes for diſcovering its quantity are generally by firſt diſcovering the linear deviation; and, in many caſes, particularly in our philoſophical inquiries, this linear deviation is our principal object. Hence it has happened, that the mathematician has frequently ſtopped ſhort at this reſult, and has adapted his theorems chiefly to this determination. Theſe differences of object have cauſed great confuſion in the methods of conſidering curvature, and led to many diſputes about its nature, and about the angle of contact; to which diſputes there will be no end, till mathematicians have agreed in their manner of expreſſing the meaſures of curvature. At preſent we abide by the meaſure already given, and we mean to expreſs by curvature or flexure the change of direction.

This being premiſed, we obſerve, that the curvature of all theſe curves of evolution where they ſeparate from their evolutes, is incomparable with the curvature in any other place. In this point the radius has no magnitude; and therefore the curvature is ſaid to be infinitely great. On the other hand, if the evolved curve has an aſſymptote, the curvature of the evolutrix of the adjacent branch is ſaid to be infinitely ſmall. Theſe expreſſions becoming familiar, have occaſioned ſome very intricate queſtions and erroneous notions. There can be little doubt of their impropriety: For when we ſay, that the curvature at A is infinitely greater than at *a*, we do not recollect that the flexure of the whole arch A *b* is equal to that of the whole arch *a* ", and the flexure at A muſt either make a part of the whole flexure, or it muſt be ſomething diſparate.

The evolutrix A *b c d f* (fig. 2.) of the common equilateral hyperbola exhibits every poſſible magnitude of curvature in a very ſmall ſpace. At the vertex A of the hyperbola it is perpendicular to the curve; and therefore has the tranſverſe axis A *r* A′ for its tangent. The curvature of the evolutrix at A is called infinitely great. As the thread unlaps from the branch ABC, its extremity deſcribes A *b c*. It is plain, that the evolutrix muſt cut the aſſymptote *r* H at right angles in ſome point G, where the curvature will be what is called infinitely ſmall; becauſe the centre of curvature has removed to an infinite diſtance along the branch AF of the hyperbola. This evolutrix may be continued to the vertex of the hyperbola on the other ſide of the aſſymptote, by cauſing the thread to lap upon it, in the ſame way that Mr Huyghens completed his cycloidal oſcillation. Or we may form another evolutrix *α δ γ δ ρ ν δ′ β′* A″, by lengthening the thread from G to *r*, the centre of the hyperbola, and ſuppoſing that, as ſoon as the curve A *δ ρ* is completed, by unlapping the thread from the branch ABC, another thread laps upon the hyperbola A″ F″. This laſt is conſidered as a more geometrical evolution than the other: For the mathematicians, extending the doctrine of evolution beyond Mr Huyghens's reſtriction to curves which had their convexity turned one way, have agreed to conſider as one continued evolution whatever will complete the curve expreſſed by one equation. Now the ſame equation expreſſes both the curves AF and A″F″, which occupy the ſame axis AA′. The cycloid employed by Huyghens is, in like manner, but one continuous curve, deſcribed by the continued provolution of the circle along the ſtraight line, although it appears as two branches of a *repeated* curve. We ſhall meet with many inſtances of this ſeemingly compounded evolution when treating of the ſecond queſtion.

Since the arch A *b d* G contains every magnitude of curvature, it appears that every kind of curvature may be produced by evolution. We can have no conception of a flexure that is greater than what we ſee at A, or leſs than what we ſee at G; yet there are caſes which ſeem to ſhew the contrary, and are familiarly ſaid, by the greateſt mathematicians, to exhibit curvatures infinitely ſmaller ſtill. Thus, let ABC (fig. 3.) be a conical parabola, whoſe parameter is AP. Let AEF be a cubical parabola, whoſe parameter is AQ. If we make AQ to AD as the cube of AP to the cube of AQ, the two parabolas will interſect each other in the ordinate DB. For, making AP $= p$, and AQ $= q$, and calling the ordinate of the conic parabola y, that of the cubic parabola z, and the indeterminate abſciſſa AD x, we have

$$p^3 : q^3 = q : x, = q^3 : z^3, \text{ and } p : q = q : z;$$

but $q : p = q : p$; therefore, by compoſition,

$$p^2 : q^2 = q^2 : px = q^2 : y^2, \text{ and } p : q = q : y;$$

therefore $z = y$, and the parabolas interſect in B.

Now, becauſe in all parabolas the ordinates drawn at the extremity of the parameters are equal to the parameters

meters, the interſections q and p will be in a line A q p, which makes half a right angle with the axis AP. Therefore, when AQ is greater than AP, the point q is without the conical parabola, and the whole arch of the cubical parabola cut off by the ordinate DB is alſo without it; but when AQ is leſs than AP, q is within the conical parabola, as is alſo the arch q B. Therefore the remaining arch BEA is without it, and is therefore leſs incurvated at A. An endleſs number of conical parabolas of ſmaller curvature may be drawn by enlarging AP; yet there will ſtill be an arch AEB of the cubical parabola which is without it, and therefore leſs incurvated. Therefore the curvature of a cubical parabola is leſs than that of any conical parabola: It is ſaid to be infinitely leſs, becauſe an infinity of cubical parabolas of *ſmaller curvature* than AEB may be drawn by enlarging AQ.

It may be demonſtrated in the ſame manner, that a paraboloid, whoſe ordinates are in the ſubbiquadrate ratio of the abſciſſæ, has an infinitely ſmaller curvature at the vertex than the cubical parabola. And the curvature of the paraboloid of the next degree is infinitely leſs than this; and ſo on continually. Nay, Sir Iſaac Newton, who firſt took notice of this remarkable circumſtance, demonſtrates the ſame thing of an endleſs ſucceſſion of paraboloids interpoſed between any two degrees of this ſeries. *Neque novit* (ſays he) *natura limitem.*

If this be the caſe, all curves cannot be deſcribed by evolution; for we have no conception of a radius of curvature that is greater than a line without limit. The theory of curvilineal motions delivered in the article DYNAMICS muſt be imperfect, or there muſt be curve lines which bodies cannot deſcribe by any powers of nature. The theory there delivered profeſſes to teach how a body can be made to deſcribe the cubical parabola, and many other curves which have theſe infiniteſimal curvatures; and yet its demonſtrations employ the radius of curvature, and cannot proceed without it. We profeſs ourſelves obliged to an attentive reader (who has not favoured us with his name) for making this obſervation. It merits attention.

There muſt be ſome paralogiſm or miſconception in all this language of the mathematicians. It does not neceſſarily follow from the arch AEB lying without the arch AIB, that it is leſs incurvated at A; it may be more incurvated between A and B. Accordingly we ſee, that the tangent BT of the conical parabola is leſs inclined to the common tangent AV than the tangent B t of the cubical parabola is; and therefore the flexure of the whole arch AEB is greater than that of the whole arch AIB; and we ſhall ſee afterwards, that there is a part of AEB that is more incurvated than any part of AIB. There is nothing correſponding to this unmeaning and inconceivable ſucceſſion of ſerieſes of magnitudes of one kind, each of which contains an endleſs variety of individuals, and the greateſt of one ſeries infinitely leſs than the ſmalleſt of the next, &c.; there is nothing like this demonſtrated by all our arguments. In none of theſe do we ever treat of the curvature at A, but of a curvature which is *not* at A. At A we have none of the lines which are indiſpenſably neceſſary for the demonſtration. Beſides, in the very ſame manner that we can deſcribe a cubical parabola, and prove that it has an arch lying without the conical parabola, we can deſcribe a circle, and demonſtrate that it has alſo an arch lying without the parabola. Theſe infiniteſimal curvatures, therefore, are not warranted by our arguments, nor does it yet appear that there are curves which cannot be deſcribed by evolution. We are always puzzled when we ſpeak of infinites and infiniteſimals as of ſomething preciſe and determinate; whereas the very denomination precludes all determination. We take the diſtinguiſhing circumſtance of thoſe different orders for a thing clearly underſtood; for we build much on the diſtinction. We conceive the curvature of the cubical parabola as verging on that of the common parabola, and the one ſeries of curvatures as beginning where the other ends. But Newton has ſhewn, that between theſe two ſerieſes an endleſs number of ſimilar ſerieſes may be interpoſed. The very names given to the curvature at the extremities of the hyperbolic evolutrix have no conceptions annexed to them. At the vertex of the hyperbola there is no line, and at the interſection with the aſſymptote there is no curvature. Theſe unguarded expreſſions, therefore, ſhould not make us doubt whether all curves may be deſcribed by evolution. If a line be incurvated, it is not ſtraight. If ſo, two perpendiculars to it muſt diverge on one ſide, and muſt converge and meet on the other in ſome point. This point will lie between two other points, in which the two perpendiculars touch that curve by the evolution, of which the given arch of the curve may be deſcribed. Finally (which ſhould decide the queſtion), we ſhall ſee by and bye, that the cubic, and all higher orders of paraboloids, may be ſo deſcribed by evolution from curves having aſſymptotic branches of determinable forms.

Such are the general affections of lines generated by evolution. They are not, properly ſpeaking, peculiar properties; for the evolutrixes may be any curve lines whatever. They only ſerve to mark the mutual relations of the evolutes with their evolutrixes, and enable us to conſtruct the one, and to diſcover its properties by means of our knowledge of the other. We proceed to ſhew how the properties of the evolutrix may be determined by our knowledge of the evolute.

This problem will not long occupy attention, being much limited by the conditions. One of the firſt is, that the length of the thread evolved muſt be known in every poſition: Therefore the length of the evolved arch muſt, in like manner, be known; and this, not only *in toto*, but every portion of it. Now this is not univerſally, or even generally the caſe. The length of a circular, parabolic, hyperbolic, arch has not yet been determined by any finite equation, or geometrical conſtruction. Therefore their evolutrixes cannot be determined otherwiſe than by approximation, or by compariſon with other magnitudes equally undetermined. Yet it ſometimes happens, that a curve is diſcovered to evolve into another of known properties, although we have not previouſly diſcovered the length of the evolved arch. Such a diſcovery evidently brings along with it the rectification of the evolute. Of this we have an inſtance in the very evolution which gave occaſion to the whole of this doctrine; namely, that of the cycloid; which we ſhall therefore take as our firſt example.

Let ABC (fig. 5.) be a cycloid, of which AD is the axis, and AHD the generating circle, and AG a tangent to the cycloid at A, and equal to DC. Let

Involution. BKE touch the cycloid in B, and cut AG in K. It is required to find the situation of that point of the line BE which had unfolded from A?.

Draw BH parallel to the base DC of the cycloid, cutting the generating circle in H, and join HA. Describe a circle KEM equal to the generating circle AHD, touching AG in K, and cutting BK in some point E. It is known, by the properties of the cycloid, that BK is equal and parallel to HA, and that BH is equal to the arch A *b* H. Because the circles AHD and KEM are equal, and the angles HAK and AKE are equal, the chords AH and KE cut off equal arches, and are themselves equal. Because BHAK is a parallelogram, AK is equal to HB; that is, to the arch A *b* H, that is, to the arch K *m* E. But if the circle KEM had been placed on A, and had rolled from A to K, the arch disengaged would have been equal to AK, and the point which was in contact with A would now be in E, in the circumference of a cycloid AEF, equal to CBA, having the line AG, equal and parallel to DC, for its base, and GF, equal and parallel to DA, for its axis. And if the diameter KM be drawn, and EM be joined, EM touches the cycloid AEF.

Cor. The arch BA of the cycloid is equal to twice the parallel chord HA of the generating circle: For this arch is equal to the evolved line BKE; and it has been shewn, that EK is equal to KB, and BE is therefore equal to twice BK, or to twice HA. This property had indeed been demonstrated before by Sir Christopher Wren, quite independent of the doctrine of evolution; but it is given here as a legitimate result of this doctrine, and an example of the use which may be made of it. Whenever a curve can be evolved into another which is susceptible of accurate determination, the arch of the evolved curve is determined in length; for it always makes a part of the thread whose extremity describes the evolutrix, and its length is found, by taking from the whole length of the thread that part which only touches the curve at its vertex.

This genesis of the cycloid AEF, by evolution of the cycloid ABC, also gives the most palpable and satisfactory determination of the area of the cycloid. For since BE is always parallel to AH, AH will sweep over the whole surface of the semicircle AHD, while BE sweeps over the whole space CBAEF; and since BE is always double of the simultaneous AH, the space CBAEF is quadruple of the semicircle AHD. But the space described in any moment by BK is also one fourth part of that described by BE. Therefore the area GAEF is three times the semicircle AHD; and the space DHABC is double of it; and the space CBAG is equal to it.

Sir Isaac Newton has extended this remarkable property of evolving into another curve of the same kind to the whole class of epicycloids, that is, cycloids formed by a point in the circumference of a circle, while the circle rolls on the circumference of another circle, either on the convex or concave side; and he has demonstrated, that they also may all be rectified, and a space assigned which is equal to their area (See *Principia*. B. I. prop. 48. &c.). He demonstrates, that the whole arch is to four times the diameter of the generating circle as the radius of the base is to the sum or difference of those of the base and the generating circle. We recommend these propositions to the attention of the young reader who wishes to form a good taste in mathematical researches; he will there see the geometrical principles of evolution elegantly exemplified.

We may just observe, before quitting this class of curves, that many writers, even of some eminence, in their compilations of elements, give a very faulty proof of the position of the tangent of a curve described by rolling. They say, for example, that the tangent of the cycloid at E is perpendicular to KE; because the line KE is, at the moment of description, turning round K as a momentary centre. This, to be sure, greatly shortens investigation; and the inference is a truth, not only when the rolling figure is a circle rolling on a straight line, but even when any one figure rolls on another. Every point of the rolling figure really *begins* to move perpendicularly to the line joining it with the point of contact. But this genesis of the arch E *e*, by the evolution of the arch B *b*, shews that K is by no means the centre of motion, nor HK the radius of curvature. Nor is it, in the case of epicycloids, trochoids, and many curves of this kind, a very easy matter to find the momentary centre. The circle KEM is both advancing and turning round its centre, and these two motions are equal, because the circle does not slide but roll, the detached arch being always equal to the portion of the base which it quits. Therefore, drawing the tangents E *g*, M *g*, and completing the parallelogram E *f* M *g*, E *f* will represent the progressive motion of the centre, and E *g* the motion of rotation. EM, the motion compounded of these, must be perpendicular to the chord EK.

The investigation that we have given of the evolutrix of the cycloid has been somewhat peculiar, being that which offered itself to Mr Huyghens at the time when he and many other eminent mathematicians were much occupied with the singular properties of this curve. It does not serve, however, so well for exemplifying the general process. For this purpose, it is proper to avail ourselves of all that we know of the cycloid, and particularly the equality of its arch BA to the double of the parallel chord HA. This being known, nothing can be more simple than the determination of the evolutrix, either by availing ourselves of every property of the cycloid, or by adhering to the general process of referring every point to an abscissa by means of perpendicular ordinates. In the first method, knowing that BE is double of BK, and therefore KE equal to HA, and KA = BH, = H *b* A, = K *m* E, we find E to be the describing point of the circle, which has rolled from A to K. In the other method, we must draw EN perpendicular to AG; then, because the point E moves, during evolution, at right angles to BE, EK is the normal to the curve described, and NK the subnormal, and is equal to the corresponding ordinate H I of the generating circle of the cycloid ABC. This being a characteristic property of a cycloid, E is a point in the circumference of a cycloid equal to the cycloid ABC.

Or, lastly, in accommodation to cases where we are supposed to know few of the properties of the evolute, or, at least, not to attend to them, we may make use of the fluxionary equation of the evolute to obtain the fluxionary equation of the evolutrix. For this purpose, take a point *e* very near to E, and draw the evolving radius *b e*, cutting E *f* (drawn parallel to the base DC) in *o*; draw *e n* parallel to the axis of the evolute, cut-

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ting E o in v; alſo draw bbi parallel to the baſe, and B d perpendicular to it. If both curves be now referred to the ſame axis CGF, it is plain that B b, B d, and db are ultimately as the fluxions of the arch, abſciſs, and ordinate of the evolute, and that E e, ev, and v E, are ultimately as the fluxions of the arch, abſciſſa, and ordinate of the evolutrix. Alſo the two fluxionary triangles are ſimilar, the ſides of the one being perpendicular, reſpectively, to thoſe of the other. If both are referred to one axis, or to parallel axes, the fluxion of the abſciſſa of the evolute is to that of its ordinate, as the fluxion of the ordinate of the evolutrix is to that of its abſciſſa. Thus, from the fluxionary equation of the one, that of the other may be obtained. In the preſent caſe, they may be referred to AD and FG, making CG equal to the cycloidal arch CBA. Call this a; AI, x; IB, y; and AB, or EB, z. In like manner, let F t be $= u$, t E $= v$, and FE $= w$; then, becauſe $DH^2 = DA^2 - AH^2$, and DA and AH are the halves of CF and BE, we have $DH^2 = \frac{a^2 - z^2}{4}$. Alſo $DI = \frac{DH^2}{DA} = \frac{a^2 - z^2}{4 \times \frac{1}{2} a}, = \frac{a^2 - z^2}{2a}$. But DI $=$ F t. Therefore F t, or u, $= \frac{a^2 - z^2}{2a}$. Alſo $\dot{w} = \frac{\dot{u}\,\dot{z}}{\dot{y}}$, by what was ſaid above, that is, $\dot{w} = \frac{a\,\dot{u}}{\sqrt{a^2 - z^2}}, = \frac{a\,\dot{u}}{\sqrt{2au}}$. Therefore we have $\dot{w} : \dot{u}\ (= a : \sqrt{2au}) = \sqrt{\tfrac{1}{2}a} : \sqrt{u} = \sqrt{GF} : \sqrt{Ft}$, which is the analogy competent to a cycloid whoſe axis is GF $=$ DA.

It is not neceſſary to inſiſt longer on this in this place; becauſe all theſe things will come more naturally before us when we are employed in deducing the evolute from its evolutrix.

When the ordinates of a curve converge to a centre, in which caſe it is called a radiated curve, it is moſt convenient to conſider its evolutrix in the ſame way, conceiving the ordinates of both as inſiſting on the circumference of a circle deſcribed round the ſame centre. Spirals evolve into other ſpirals, and exhibit ſeveral properties which afford agreeable occupation to the curious geometer. The equiangular, logarithmic, or loxodromic ſpiral, is a very remarkable example. Like the cycloid, it evolves into another equal and ſimilar equiangular ſpiral, and is itſelf the evolutrix of a third. This is evident on the ſlighteſt inſpection. Let C rqp (fig. 6.) be an equiangular ſpiral, of which S is the centre; if a radius SC be drawn to any point C, and another radius SP be drawn at right angles to it, the intercepted tangent CP is known to be equal to the whole length of the interior revolutions of the ſpiral, though infinite in number. If the thread CP be now unlapped from the arch C rq, it is plain that the firſt motion of the point P is in a direction PT, which is perpendicular to PC, and therefore cuts the radius PS in an angle SPT, equal to the angle SCP; and, ſince this is the caſe in every poſition of the point, it is manifeſt that its path muſt be a ſpiral PQR, cutting the radii in the ſame angle as the ſpiral C rqp. James Bernoulli firſt diſcovered this remarkable property. He alſo remarked, that if a line PH be drawn from every point of the ſpiral, making an angle with the tangent equal to that made by the radius (like an angle of reflection correſponding with the incident ray SP), thoſe reflected rays would all be tangents to another ſimilar and equal ſpiral I v H; ſo that PH $=$ PS. S and H are conjugate foci of an infinitely ſlender pencil; and therefore the ſpiral I v H is the cauſtic by reflection of RQP for rays flowing from S. If another equal and ſimilar ſpiral xvy roll on I v H, its centre z will deſcribe the ſame ſpiral in another poſition ouz. All theſe things flow from the principles of evolution alone: and Mr Bernoulli traces, with great ingenuity, the connection and dependence of cauſtics, both by reflection and refraction, of cycloidal, and all curves of provolution, and their origin in evolution or involution. A variety of ſuch repetitions of this curve (and many other ſingular properties), made him call it the SPIRA MIRABILIS. He deſired that it ſhould be engraved on his tombſtone, with the inſcription EADEM MUTATA RESURGO, as expreſſive of the reſurrection of the dead. See his two excellent diſſertations in *Act.* Erudit. 1692, March and May.

Another remarkable property of this ſpiral is, that if, inſtead of the thread evolving from the ſpiral, the ſpiral evolve from the ſtraight line PC, the centre S will deſcribe the ſtraight line PS. Of this we have an example in the apparatus exhibited in courſes of experimental philoſophy, in which a double cone deſcends. by rolling along two rulers inclined in an angle to other (ſee *Graveſande's* Nat. Phil. I. § 21). It is pretty remarkable, that a rolling [illegible] ſeemingly round C, as a momentary centre, ſhould produce a motion in the ſtraight line SP; and it ſhews the inconcluſiveneſs of the reaſoning, by which many compilers of elements of geometry profeſs to demonſtrate, that the motion of the deſcribing point S is perpendicular to the momentary radius. For here, although this ſeeming momentary radius may be ſhorter than any line that can be named, the real radius of curvature is longer than any line that can be named.

But it is not merely an object of ſpeculative geometric curioſity to mark the intimate relation between the geneſis of curves by evolution and provolution; it may be applied to important purpoſes both in ſcience and in art. Mr M'Laurin has given a very inviting example of this in his account of the Newtonian philoſophy; where he exhibits the moon's path in abſolute ſpace, and from this propoſes to inveſtigate the deflecting forces, and *vice verſa*. We have examples of it in the arts, in the formation of the pallets of pendulums, the teeth of wheels, and a remarkable one in Meſſrs Watt and Boulton's ingenious contrivance for producing the rectilineal motion of a piſton rod by the combination of circular motions. M. de la Hire, of the Academy of Sciences at Paris, has been at great pains to ſhew how all motions of evolution may be converted into motions of provolution, in a memoir in 1706. But he would have done a real ſervice, if, inſtead of this ingenious whim, he had ſhewn how all motions of provolution may be traced up to the evolution which is equivalent to them. For there is no organic geneſis of a curvilineal motion ſo ſimple as the evolution of a thread from a curve. It is the primitive geneſis of a circle; and it is in evolution alone that any curvilineal motion is comparable with circular motion. A given curve line is an individual, and therefore its primitive organical geneſis muſt alſo be individual. This is ſtrictly true of evolution. A parabola

Involution. bola has but one evolute. But there are infinite motions of provolution which will describe a parabola, or any curve line whatever; therefore these are not primitive organical modes of description. That this, however, is the case, may be very easily shewn. Thus let ABCD (fig. 7.) be a parabola, or any curve; and let $abcd$ be any other curve whatever. A figure $E\,m\,l\,k\,hi$ may be found such, that while it rolls along the curve $abcd$, a point in it shall describe the parabola. The process is as follows: Let Bb, Cc, Dd, &c be a number of perpendiculars to the parabola, cutting the curve $abcd$ in so many points. The perpendiculars may be so disposed that the points a, b, c, &c. shall be equidistant. Now we can construct a triangle Eeh so, that the three sides Ee, eh, and hE, shall be respectively equal to the three lines Ee, ef, Ff. In like manner may the whole figure be constructed, having the little bases of the triangles respectively equal to the successive portions of the base Abcd, and the radii equal to the perpendiculars Bb, Cc, Dd, &c. Let this figure roll on this base c. While the little side ek moves from its present position, and applies itself to ef, the point E describes an arch Ee of a circle round the centre e, and, falling within the parabola, is somewhere between E and F. Then continuing the provolution, while the next side hi turns round f till i applies to g, the point E describes another arch eFo round f, first rising up and reaching the parabola in F, when the line hE coincides with fF, and then falling within the parabola till the point h begin to rise again from f by the turning of the rolling figure round the point g. Reversing the motion, the sides ih, he, ek, &c. apply themselves in succession to the portions gf, fe, ed, &c. of the base, and the point E describes an undulating line, consisting of arches of circles round the successive centres g, f, e, &c. These circular arches all touch the parabola in the points G, F, E, &c. and separate from it a little internally. By diminishing the portions of the base, and increasing the number of the triangular elements of the rolling figure without end, it is evident that the figure becomes ultimately curvilineal instead of polygonal, and the point E continues in the parabola, and accurately describes it. It is now a curvilineal figure, having its elementary arches equal to the portions of the base to which they apply in succession, and the radii converging to E equal to the perpendiculars intercepted between the curve ABCD and the base. It may therefore be accurately constructed.

It is clear, that practical mechanics may derive great advantage from a careful study of this subject. We now see motions executed by machinery which imitate almost every animal motion. But these have been the result of many random trials of *wipers*, *snail-pieces*, &c of various kinds, repeatedly corrected, till the desired motion is at last accomplished. But it is, as we see, a scientific problem, to construct a figure which shall certainly produce the proposed motion; nor is the process by any means difficult. But how simple, in comparison, is the production of this motion by evolution We have only to find the curve line which is touched by all the perpendiculars Bb, Cc, Dd, &c. This naturally leads us to the second problem in this doctrine, namely, to determine the evolute by our knowledge of the involute: a problem of greater difficulty and of greater importance, as it implies, and indeed teaches, the curvature of lines, its measure, and the law of its variation in all particular cases. The evolute of a curve is the geometrical expression, and exhibition to the eye, of both these affections of curve lines. Involution.

Since the evolved thread is always at right angles to the evolutrix and its tangent, and is itself always a tangent of the evolute, it follows, that all lines drawn perpendicular to the arch of any curve, touch the curve line which will generate the given curve by evolution. Were this evolved curve previously known to us, we could tell the precise point where every perpendicular would touch it; but this being unknown, we must determine the points of contact by some other method, and by this determination we ascertain so many points of the evolute. The method pursued is this: When two perpendiculars to the proposed curve are not parallel (which we know from the known position of the tangents of our curve), they must intersect each other somewhere on that side of the tangents where they contain an angle less than 180°. But when they thus interfect, one of them has already touched the evolute, and the other has not yet reached it. Thus let bs, es (fig. 1.) be the two perpendiculars: being tangents to the evolute, the point s of their intersection must be on its convex side, and the unknown points of contact B and E must be on different sides of s. These are elementary truths.

Let eE approach toward bB, and now cut it in x. The contact has shifted from E to D, and x is still between the contacts. When the shifting perpendicular comes to the position cC, the intersection is at i, between the contacts B and C. And thus we see, that as the perpendiculars to the involute gradually approach, their contacts with the evolute also approach, and their intersection is always between them. Hence it legitimately follows, that the ultimate position of the intersection (which alone is susceptible of determination by the properties of the involute) is the position of the point of contact, and therefore determines a point of the evolute. The problem is therefore reduced to the investigation of this ultimate intersection of two perpendiculars to the proposed curve, when they coalesce after gradually approaching. This will be best illustrated by an example: Therefore let ABC (fig. 8.) be a parabola, of which A is the vertex, AH the axis, and AV one-half of the parameter; let BE and CK be two perpendiculars to the curve, cutting the axis in E and K, and intersecting each other in r; draw the ordinates BD, CV, and the tangent BT, and draw BF parallel to the axis, cutting CK in F, and CN in O.

Because the perpendiculars intersect in r, we have rE : EB = EK : BF. If therefore we can discover the ratio of EK to BF, we determine the intersection r. But the ratio of EK to BF is compounded of the ratio of EK to BO, and the ratio of BO to BF. The first of these is the ratio of equality; for DE and VK are, each of them, equal to AV, or half the parameter. Take away the common part VE, and the remainders EK and DV are equal, and DV is equal to BO; therefore EK : BF = BO : BF; therefore rE : rB = FO : BF, and (by division) BE : Br = FO : OB. Now let the point C continually approach to B, and at last unite with it. The intersection r will unite with a point of contact N on the evolute. The ultimate ratio of FO to OB, or of fo : oB, is evidently that of ED to

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to DT, or ED to 2DA; therefore BE : EN = ED : 2DA, or as half the parameter to twice the abſciſſa. Thus have we determined a point of the evolute; and we may, in like manner, determine as many as we pleaſe.

But we wiſh to give a general character of this evolute, by referring it to an axis by perpendicular ordinates. It is plain that V is one point of it, becauſe the point E is always diſtant from its ordinate DB by a line equal to AV; and therefore, when B is in A, E will be in V, and r will coincide with it. Now draw VP and NQ perpendicular to AH, and NM perpendicular to VP; let EB cut PV in t: then, becauſe AV and DE are equal, AD is equal to VE, and VE is equal to one-half of DT. Moreover, becauſe BD and NQ are parallel, DE : EQ = BE : EN = DE : DT; therefore DT = EQ, and VE = $\frac{1}{2}$EQ, and therefore = $\frac{1}{3}$VQ; therefore Vt is $\frac{1}{3}$ of Mt, and $\frac{1}{4}$MV. This is a characteriſtic property of the evolute. The ſubtangent is $\frac{3}{2}$ of the abſciſſa; in like manner, as in the common parabola, it is double of the abſciſſa. We know therefore that the evolute is a paraboloid, whoſe equation is $p\,x^2 = y^3$; that is, the cube of any ordinate MN is equal to the parallelopiped whoſe baſe is the ſquare of the abſciſſa VM, and altitude a certain line VP, called the parameter. To find VP, let CR be the perpendicular to the parabola in the point where it is cut by the ordinate at V; draw the ordinate RS of the paraboloid, and RG perpendicular to AH. Then it is evident, from what has been already demonſtrated, that VK is $\frac{1}{2}$ of KG, and $\frac{1}{3}$ of VG; therefore $KG^2 = 4VK^2$, and (in the parabola) $VC^2 = 2VK^2$. Alſo, becauſe KV : VC = KG : GR, we have $GR^2 = 2KG^2 = 8VK^2$; therefore $VP \times RG^2 = 8VP \times VK^2$. But $VG^3 = 27VK^3, = 27VK \times VK^2$; therefore, becauſe in the paraboloid $VP \times VS^2, = SR^3$, or $VP \times RG^2 = VG^3$, we have $8VP \times VK^2 = 27VK \times VK^2$, and $8VP = 27VK$; or VK : VP; that is, AV : VP = 8 : 27; or VP = $\frac{27}{8}$ AV, or $\frac{27}{16}$ of the parameter of the parabola ABC. The evolute of the conical parabola is the curve called the ſemicubical parabola, and its parameter is $\frac{27}{16}$ of the conical parabola.

This inveſtigation is nearly the ſame with that given by Huyghens, which we prefer at preſent to the method generally employed, becauſe it keeps the principle of inference more cloſely in view.

Mr Huyghens has deduced a beautiful corollary from it. Since the parabola ABC is deſcribed by the evolution of the paraboloid VNR, the line RC is equal to the whole evolved arch RNV, together with the redundant tangent line AV. If therefore we take from CR a part Cx equal to the redundant AV, the remainder xR is equal to the arch RNV of the paraboloid. We may do this for every poſition of the evolved radius, and thus obtain a ſeries of points V, β, γ, δ, ϵ, of the evolutrix of the paraboloid. We have even an eaſier method for obtaining the length of any part of the arch of the paraboloid, without the previous deſcription of the parabola ABC. Suppoſe Py the arch of the paraboloid, and yz the tangent; make Pz = $\frac{8}{27}$ of the parameter, and deſcribe the arch P$u\,u$ of a circle; then draw from every tangent $y\,z$ a parallel line $x\,v$, cutting the circle in u. The length of the arch yP is equal to $y\,z + u\,v$. The celebrated author congratulates himſelf, with great juſtice, on this neat exhibition of a right line equal to the arch of a curve, without the employment of any line higher than the circle. It is the ſecond curve that has been ſo rectified, the cycloid alone having been rectified by plain geometry a very few years before by Sir Chriſtopher Wren. It is very true, and he candidly admits it, that this very curve had been rectified before by Mr William Neill, a young gentleman of Oxford, and favourite pupil of Dr Wallis; as alſo by Mr Van Heuraet, a Dutch gentleman of rank, and an eminent mathematician. But both of theſe gentlemen had done it by means of the quadrature of a curve, conſtructed from the paraboloid after the manner of Dr Barrow, *Lect. Geom.* XI. Nor was this a ſolitary diſcovery in the hands of Mr Huyghens, as the rectification of the cycloid had been in thoſe of Sir Chriſtopher Wren; for the method of inveſtigation furniſhed Mr Huyghens with a general rule, by which he could evolve every ſpecies of paraboloid and hyperboloid, two claſſes of curves which come in the way in almoſt every diſcuſſion in the higher geometry. He obſerves, that the ratio of Bf to Ee, being always compounded of the ratios of Bf to Bo, and of Bo, or Dd, to Ee; and the ultimate ratio of Bf to Bo being that of TE to TD, which is given by the nature of the paraboloid, we can always find the ratio of BE to BN, if we know that of Dd to Ee. In all curves, the ratio of Dd to Ee (taken indefinitely near), is that of the ſubtangent to the ſum of the ſubtangent and ordinate of a curve conſtructed on the ſame abſciſſa, having its ordinates equal to the ſubnormals DE, de, VK, &c. In the conic ſections the ratio is conſtant, becauſe the line ſo conſtructed is a ſtraight line; and, in the parabola, it is parallel to the axis. See farther properties of it in Barrow's *Lect. Geom.* XI.

From this inveſtigation, Mr Huyghens has deduced the following beautiful theorem:

Let a be the parameter of the paraboloid, x its abſciſſa, and y its ordinate; and let the equation be $a^m x^n = y^{m+n}$; let the radius of the evolute meet the tangent through the vertex A in Z. We ſhall always have $BN = \frac{n}{m} BE + \frac{m+n}{m} BZ$. Thus,

$$\text{If}\ \left.\begin{array}{l} a\,x = y^2 \\ a^2 x = y^3 \\ a \\ a\,x^3 = y^4 \\ a^3 x = y^4 \end{array}\right\}\ \text{then } BN = \left\{\begin{array}{l} BE + 2BZ \\ \frac{1}{2}BE + \frac{3}{2}BZ \\ 2BE + 3BZ \\ 3BE + 4BZ \\ \frac{1}{3}BE + \frac{4}{3}BZ \end{array}\right.$$

&c. &c.

This is an extremely ſimple and perſpicuous method of determining the radius of the evolute, or radius of curvature; and it, at the ſame time, gives us the rectification of many curves. It is plain that every geometrical curve may be thus examined, becauſe the ſubnormals DE, VK are determined; and therefore their differences are determined. Theſe differences are the ſame with the differences of Dd and Ee; and therefore the ratio of Dd to Ee is determined; that is, the ſubſidiary curve now mentioned can always be conſtructed.

There is a ſingular reſult from this rule, which would hardly have been noticed, if the common method for determining BN had alone been employed. The equation of the paraboloid is ſo ſimple, that the increaſe of the ordinates and diminution of curvature ſeem to keep pace together; yet we have ſeen that, in the vertex of the cubical parabola, the curvature is leſs than any circular curvature that can be named. In the legs, the curvature certainly diminiſhes as they extend farther;

there must therefore be some intermediate point where the curvature is the greatest possible. This is distinctly pointed out by Mr Huyghens's theorem. The evolute of this paraboloid (having $a^3x = y^4$) is a curve ONRNQ (fig. 9.) consisting of two branches RO, and RQ, which have a common tangent in R; the branch RQ has the axis AE for its assymptote. The thread unfolding from OR, its extremity, describes the arch EC, and then, unfolding from RQ, it describes the small arch CBA. When E is extremely near A, the thread has a position BNE, in which EN is very nearly $\frac{4}{3}$BE. At C, if CE be bisected in G, GR is $\frac{1}{3}$ of CZ. Here CR the radius of curvature is the shortest possible. The evolutes of all paraboloids consist of two such branches, if $m + n$ exceeds 2.

Such is the theory of evolution and involution as delivered by Mr Huyghens about the year 1672. It was cultivated by the geometers with success. Newton prized it highly, and gave a beautiful specimen of its application to the description, rectification, and quadrature of epicycloids, trochoids, and epicycles of all kinds. But it was eclipsed by the fluxionary geometry of Newton, which included this whole theory in one proposition, virtually the same with Mr Huyghens's, but more comprehensive in its expression, and much more simple in its application. Adopting the unquestionable principle of Mr Huyghens, that the evolved thread is the radius of a circle which has the same flexures with the curve, the point of the evolute will be obtained by finding the length of the radius of the equicurve circle. The formula for this purpose is given in the article FLUXIONS of the *Encyclopædia Britannica*; but is incorrectly stated $= \frac{\overline{a+4}|^{\frac{3}{2}}}{2\sqrt{a}}$, instead of $\frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}}$. The theorem also from which it is deduced $\left(r = \frac{\dot z^3}{-\dot x\ddot y}\right)$ is incorrectly printed, and is given without any demonstration, thereby becoming of very little service to the reader. For which reason, it is necessary to supply the defect in this place.

Therefore let AbcdEf (fig. 10.) be a circle, of which C is the centre, and ACE a diameter; let the points b, c, d, of the circumference be referred to this diameter by the equidistant perpendicular ordinates bi, cg, dk; draw the chords bc, cd, producing dc till it meet the ordinate bi in a, produce cg to the circle in f, and join bf, df; draw bh, cm, perpendicular to the ordinates; then bh, cm, hc, md, bc, cd, are ultimately proportional to the first fluxions of the abscissa AE, the ordinate cg, and the arch Ac; also ab, the difference between dm and ch is ultimately as the second fluxion of the ordinate. The triangle abc is similar to bdf; for the angle abc is equal to the alternate angle bcf, which is equal to bdf, standing on the same segment. The angle acb is equal to bfd, standing on the segment bcd; therefore the remaining angles bac and dbf are equal; therefore $ab : bc = bd : df = \frac{1}{2} bd : \frac{1}{2} df$. Now let the ordinates bi and dk continually approach the ordinate cg, and at last unite with it; we shall then have bc ultimately equal to $\frac{1}{2} bd$, and cg ultimately equal to $\frac{1}{2} df$. Therefore, ultimately, $ab : bc = bc : cg$, and $cg = \frac{bc^2}{ab}$.

Let u, v, w, represent the variable abscissa, ordinate, and arch. We have, for the fluxionary expression of the ordinate of the equicurve circle, $= \frac{\dot w^2}{-\ddot v}$ ($\ddot v$ must have the negative sign, because, as the arch increases, $\dot v$ diminishes). In the next place, it is evident that, ultimately, $bh : bc = cg : c$C, and $c\text{C} = \frac{cg \times bc}{bh}$. If r be the radius of the equicurve circle, we have $= \dot w : r$, and $r = \frac{v\dot w}{\dot u}$. But we had $v = \frac{\dot w^2}{-\ddot v}$. Substitute this in the present equation, and we obtain $r = \frac{\dot w^3}{-\dot u\ddot v}$. Lastly, observe that $\dot w^2 = \dot u^2 + \dot v^2$, and $\dot w = \sqrt{\dot u^2 + \dot v^2} = \overline{\dot u^2 + \dot v^2}|^{\frac{1}{2}}$. Therefore $\dot w^3 = \overline{\dot u^2 + \dot v^2}|^{\frac{3}{2}}$ and we have $r = \frac{\overline{\dot u^2 + \dot v^2}|^{\frac{3}{2}}}{-\dot u\ddot v}$, as the most general fluxionary expression of the radius of a circle, in terms of the sine, cosine, and arch.

When a curve and a circle have the same curvature, it is not enough that the first fluxions of their abscissæ, ordinates, and arches, are the same. This would only indicate the position of their common tangent. They must have the same deflection from that tangent. This is always equal to half of the second fluxion of the ordinate. Therefore the circle and curve must have the same second fluxion of their ordinates. Therefore let DbcdF be any curve coinciding with, or osculated by, the circle Abcd. Let its axis be DG, parallel to the diameter AE; and let cn be its ordinate. Let Dn be $= x$, $cn = y$, and $bc = z$. We have $\dot x$, $\dot y$, $\dot z$, respectively equal to $\dot u$, $\dot v$, $\dot w$. Therefore the radius of the osculating circle is $r = \frac{\dot z^3}{-\dot x\ddot y}$ or $r = \frac{\overline{\dot x^2 + \dot y^2}|^{\frac{3}{2}}}{-\dot x\ddot y}$, for all curves whatever. (We recommend the careful perusal of the celebrated 2d corollary of the 10th proposition of the 2d book of Newton's Principia, where the first principles of this doctrine are laid down with great acuteness.)

Instead of supposing the ordinates equidistant, and consequently $\dot x$ invariable, we might have supposed the ordinates to increase by equal steps. In this case y would have had no second fluxion. The radius would then be $= \frac{\dot z^3}{\dot y\ddot x}$. Or, lastly, we might suppose (and this is very usual) the arch z to increase uniformly. In this case $r = \frac{\dot z\dot y}{\ddot x}$: For because $\dot x^2 + \dot y^2 = \dot z^2$, by taking the fluxion of it, $2\dot x\ddot x + 2\dot y\ddot y = 0$, and $\ddot y = \frac{\dot x\ddot x}{-\dot y}$; and therefore $r = \frac{\dot z^3}{\dot y\ddot x - \dot x\ddot y}, = \frac{\dot z^3}{\dot y\ddot x + \frac{\dot x^2\ddot x}{\dot y}}, = \frac{\dot z^3}{\dot y^2 + \dot x^2 \times \frac{\ddot x}{\dot y}}, = \frac{\dot y\dot z}{\ddot x}$.

Having thus obtained the radius of curvature, and consequently a point of the evolute, we determine its

form

Involution.

form by reference to an abscissa, without much farther trouble: It only requires the drawing Cp perpendicular to the axis of the proposed curve, and giving the values of Cp and Dp. If we suppose $\dot{x}$ constant, then, cC being $=\frac{\dot{z}^3}{-\dot{x}\ddot{y}}$, we have Dp ($=Dn+gc$, $=Dn+\frac{\dot{y}}{\dot{z}}\times cC$) $=x+\frac{\dot{y}\dot{z}^2}{-\dot{x}\ddot{y}}$; and pC ($=cg-cn$, $=\frac{\dot{x}}{\dot{z}}\times cC-cn$) $=\frac{\dot{z}^2}{-\ddot{y}}-y$. But if we suppose $\dot{y}$ constant; then, cC being $=\frac{\dot{z}^3}{\dot{y}\ddot{x}}$, we have $Dp=x+\frac{\dot{z}^2}{\ddot{x}}$, and $pC=\frac{\dot{x}\dot{z}^2}{\dot{y}\ddot{x}}-y$. And if $\dot{z}$ be constant, then, cC being $=\frac{\dot{y}\dot{z}}{\ddot{x}}$, we shall have $Dp=x+\frac{\dot{y}^2}{\ddot{x}}$, and $pC=\frac{\dot{x}\dot{y}}{\ddot{x}}-y$.

These formulæ are so many general expressions for determining both the curvature of the proposed curve and the form of its evolute. They also give us the rectification of the evolute; because cC is equal to the evolved arch, or to that arch, together with a constant part, which was a tangent to the evolute at its vertex, in those cases where the involute has a finite curvature at its vertex; as in the common parabola.

Let us take the example of the common parabola, that we may compare the two methods. The equation of this is $ax=y^2$, or $a^{\frac{1}{2}}x^{\frac{1}{2}}=y$. This gives $\dot{y}=\frac{1}{2}a^{\frac{1}{2}}\dot{x}x^{-\frac{1}{2}}$, $=\frac{a^{\frac{1}{2}}\dot{x}}{2x^{\frac{1}{2}}}$, and (making $\dot{x}$ constant) $\ddot{y}=-\frac{1}{2}\times\frac{1}{2}a^{\frac{1}{2}}\dot{x}^2x^{-\frac{3}{2}}=\frac{-a^{\frac{1}{2}}\dot{x}^2}{4x^{\frac{3}{2}}}$. Wherefore $\dot{z}$ ($=\sqrt{\dot{x}^2+\dot{y}^2}$) $=\frac{\dot{x}}{2}\sqrt{\frac{4x+a}{x}}$, and the radius of curvature $\left(=\frac{\dot{z}^3}{-\dot{x}\ddot{y}}\right)=\frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}}$. At the vertex, where $x=0$, the formula becomes $=\frac{1}{2}a$. Again, $Dp\left(=x+\frac{\dot{y}\dot{z}^2}{-\dot{x}\ddot{y}}\right)$ becomes $\frac{1}{2}a+3x$; and therefore $Vp=3x$, = the abscissa of our evolute. Likewise cp, its ordinate, $\left(=\frac{\dot{z}^2}{-\ddot{y}}-y\right)=\frac{4x^{\frac{3}{2}}}{\sqrt{a}}$; and $Cp^2=\frac{16x^3}{a}$; and $Cp^2\times a=16x^3$. But $Vp=3x$, and $Vp^3=27x^3$. Therefore $Cp^2\times\frac{1}{16}$th $a=x^3$, $=\frac{1}{27}$th Vp^3, and $\frac{27}{16}$ths $a\times Cp^2=Vp^3$. Therefore the evolute VC is a semicubical parabola, whose parameter is $\frac{27}{16}a$, as was shewn by Mr Huyghens. The arch VC is $=\frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}}-\frac{1}{2}a$.

We shall give one other example, which comprehends the whole class of paraboloids. Their general equation is $y=ax^n$. This gives us $\dot{y}=nax^{n-1}\dot{x}$, and $\ddot{y}=n\times\overline{n-1}\times ax^{n-2}\dot{x}^2$; therefore $\dot{z}$ ($=\sqrt{\dot{x}^2+\dot{y}^2}$) $=\dot{x}\sqrt{1+n^2a^2x^{2n-2}}$; $Cc\left(=\frac{\dot{z}^3}{-\dot{x}\ddot{y}}\right)=\frac{\overline{1+n^2a^2x^{2n-2}}|^{\frac{3}{2}}}{-n\times\overline{n-1}\times ax^{n-2}}$; $Dp\left(=x+\frac{\dot{y}\dot{z}^2}{-\dot{y}\ddot{x}}\right)=x-\frac{x+n^2a^2x^{2n-1}}{n-1}$; $Cp\left(=\frac{\dot{z}^2}{\ddot{y}}-y\right)=\frac{1+\overline{2n-1}\times na^2x^{2n-2}}{-\overline{n-1}\times nax^{n-2}}$; and $DV=-\frac{n^2a^2o^{2n}}{n-1}$.

This last formula expresses the radius of curvature at the vertex D, or the redundant part of the thread, by which it exceeds the arch VC of the evolute. If $n=\frac{1}{2}$, the formula becomes $\frac{a^2}{2}$: but if n be greater than this, VC will be $=o$; and if it be less, VC will be infinite. Hence it appears, that the radius of curvature at the vertex of a curve is a finite quantity only in the cases where the first or nascent ordinates are in the subduplicate ratio of their abscissæ. In all other cases, the curvature is incomparable with that of any circle, being either what is called infinite (when n is greater than $\frac{1}{2}$) or nothing (when it is less).

We scruple not to say, that the method of Mr Huyghens is more luminous, more pleasing to the imagination of a geometer, than this; and in all the cases which occurred to us in our employment of it, it suggested more ready constructions, with the additional satisfaction of exhibiting, in a continuous train, what the *symbolical* method, proceeding by the fluxionary calculus, only indicates by points. We must also observe, that the subsidiary curve employed by Huyghens, having its ordinates equal to the subnormals of the involute under examination, is the geometrical expression of that function of the involute which gives the second fluxions $\ddot{y}$ and $\ddot{x}$ of the ordinate and abscissa. The young mathematician will find no difficulty in constructing this curve *in every case*; whereas we imagine that he will not find it a light matter to construct the final equations of the symbolic method *almost in any case*. At the same time, the all-comprehending extent of the latter method, and the numberless general theorems which it suggests to the expert analyst, give it a most deserved preference, and make it almost an indispensable instrument for all who would extend our physico mathematical sciences.

In the employment of the geometry of curve lines, especially in the doctrine of centripetal forces, it is usual to consider the ordinates, not as insisting on a rectilineal abscissa, but as diverging from a centre. This is also the usual way of conceiving all spirals and evolutrixes of curves which include space; in short, all RADIAL curves. The process for finding their evolute, or their radius of curvature, is somewhat different from that hitherto exhibited; but it is more simple. Thus, let GPM (fig. 10.) be the elliptical path of a planet, of which S is the focus. We require PC, the radius of curvature in the point P. Let Pp be a very small arch. Draw the radii SP, Sp, the tangents PT, pt; and

and draw ST perpendicular to PT, cutting pt in t; and Po perpendicular to Sp. Let the arch GP be $= z$, the radius SP $= y$, and the perpendicular ST $= p$. Then, it is plain, that Pp, op, Tt, are ultimately proportional to $\dot{z}$, $\dot{y}$, $\dot{p}$. The triangles PCp, and Tpt or TPt are alſo ultimately ſimilar; as alſo the triangles PST and poP. Therefore, ultimately,

$$\text{T}t : \text{P}p = \text{PT} : \text{PC}$$

alſo

$$\text{P}p : po = \text{PS} : \text{PT}$$

therefore Tt : po = PS : PC, or, $\dot{p} : \dot{y} = y : r$, and $r = \frac{y\dot{y}}{\dot{p}}$; an expreſſion of the radius of curvature, extremely ſimple, and of eaſy application.

The logarithmic or equiangular ſpiral PQR (fig. 6.) affords an eaſy example of the uſe of this formula. The angle SPT, which the ordinate makes with the curve, is everywhere the ſame. Therefore let a be our tabular radius, and b the ſine of the angle SPT. We have

$$\text{ST} = \frac{by}{a}\text{; and therefore PC}\left(= \frac{y\dot{y}}{\dot{p}}\right) = \frac{ay\dot{y}}{b\dot{y}} = \frac{ay}{b}.$$

This is to SP or y in the conſtant ratio of a to b, or of SP to ST: that is, ST : SP = SP : PC, the triangles SPT and PCS are ſimilar, the angles at P and C equal, and C is a point of an equiangular ſpiral pyr round the centre S.

It is not meant that the conſtruction pointed out by this theory of involution, expreſſed in its moſt general and ſimple form, is always the beſt for finding the centre of the equicurve circle. Our knowledge of, or attention to, many other properties of the curve under conſideration, beſides thoſe which ſimply mark its relation to an abſciſs and ordinate, muſt frequently give us better conſtructions. But evolution is the natural geneſis of a line of varying curvature. Moreover, in the moſt important employment of mathematical knowledge, namely, mechanical philoſophy, it is well known, that the moſt certain and comprehenſive method of ſolving all intricate problems is by reference of all forces and motions to three co-ordinates perpendicular to each other. Thus, without any intentional ſearch, we have already in our hands the very fluxionary quantities employed in this doctrine; and the expreſſion which it gives of the radius of curvature requires only a change of terms to make it a mechanical theorem.

Thus have we conſidered the two chief queſtions of evolution and involution. We have done it with as cloſe attention to geometry as poſſible, that the reader's mind may become familiar with the *ipſa corpora* while acquiring the elementary knowledge, which is to be employed more expeditiouſly afterwards by the help of the ſymbolical analyſis. Without ſuch ideas in the mind, the occupation is oftentimes as much diveſted of thought as that of an expert accountant engaged in complex calculations; the attention is wholly turned to the rules of his art.

It now remains to conſider a little the nature of this curvature of which ſo much has been ſaid, and about which ſo many obſcure opinions have been entertained. We mentioned, in an early part of this article, the unwarranted uſe of the terms of infinite and infiniteſimal magnitude as applicable to curvature, and ſhewed its impropriety by the inconſiſtences into which it leads mathematicians. Nothing threw ſo much light on this ſubject as Mr Huyghens's Geometry of Evolution; and we ſhould have expected that all diſputes would have been ended by it. But this has not been the caſe; and even the moſt eminent geometers and metaphyſicians, ſuch as the Bernoullis and Leibnitz, have given explanations of orders of curvature that can have no exiſtence, and explanations of that coaleſcence which obtains between a curve line and its equicurve circle, which are not warranted by juſt principles.

Theſe errors (for ſuch we preſume to think them) aroſe from the method employed by the geometers of laſt century for obtaining a knowledge of the magnitude and variation of curvature. The ſcrupulous geometers of antiquity deſpaired of ever being able to compare a curve with a right line. The moderns, although taught by Des Cartes to define the nature of a curve by its equation, allowed that this only enabled them to exhibit a ſeries of points through which it paſſed, and to draw the polygon which connects theſe points, but gave no information concerning the continuous *incurvated* arches, of which the ſides of the polygon are the chords. They could not generally draw a tangent to any point, or from any point; but they could draw a chord through any two points. Des Cartes was the firſt who could draw a tangent. He contrived it ſo, that the equation which expreſſes the interſections of the curve with a circle deſcribed round a given centre ſhould have two equal roots. This indicates the coaleſcence of two interſections of the common chord of the circle and the curve. Therefore a perpendicular to the radius ſo determined muſt touch the curve in the point of their union. This was undoubtedly a great diſcovery, and worthy of his genius. It naturally led the way to a much greater diſcovery. A circle may cut a curve in more points than two: It may cut a conic ſection in four points, all expreſſed by one equation, having four roots or ſolutions. What if three of theſe roots ſhould be equal? This not only indicates a cloſer union than a mere contact, but alſo gives indication of the flexure of the intervening arch. For, before the union, the interſections were in the arch both of the curve and of the circle; and therefore the diſtinction between the union of two and of three interſections muſt be of the ſame kind with that between a ſtraight line and an arch of *this* circle. The flexure of a circle being the ſame in every part, it becomes a proper index; and therefore the circle, which is determined by the coaleſcence of three interſections, was taken as the meaſure of the curvature in that point of the curve, and was called the CIRCLE OF CURVATURE, the EQUICURVE CIRCLE. There is a certain progreſs to this coaleſcence which muſt be noticed. Let ABD (fig. 4.) be a common parabola, EBF a line touching it in B, and BO a line perpendicular to EBF. Taking ſome point O in the other ſide of the axis for a centre, a circle may be deſcribed which cuts the curve in four points a, b, c, and d. By enlarging the radius, it is plain that the points a and b muſt ſeparate, as alſo the points c and d. Thus, the points b and c approach each other, and at laſt coaleſce in a point of contact B, with the parabola, and with its tangent. In the mean time, a and d have retired to A and D. If we now bring the centre O nearer to B, the new circle will fall wholly within the laſt circle ABD; and therefore both

Involution. A and D will again approach to each other, and to B, which still continues a point of contact. It is plain that A will approach faster to B than D will do. At length, the centre being in *o*, the point A coalesces with B, and we obtain a circle *ι* B *δ*, touching the curve in B, and cutting it in *δ*: Consequently the arch B *ι δ* is wholly within, and B *ν δ* is wholly without the parabola; and the circle both touches and cuts the parabola in B. Here is certainly a closer union, at least on the side of *a*. But perhaps a farther diminution of the circle may bring it closer on the side of D. Join B *δ*. Let a smaller circle be described, touching the parabola in B, and cutting it in *ν*. Draw *ν c* parallel to *δ* B. It may be demonstrated that the new circle cuts the parabola in *c*. Now the arch between *c* and *ν* being without the parabola, the arch B C must be within it; and therefore this circle is within the parabola on both sides of B, and is more incurvated than the parabola. We have seen, that a circle greater than *ι* B *δ* is without the parabola on both sides of B; and therefore is less incurvated than the parabola. Therefore the individual circle *ι* B *δ* is neither more nor less curve than the parabola in the point B. Therefore the circle indicated by the coalescence of three intersections is properly named the equicurve circle; and, since we measure all curvatures by that of a circle, it is *properly* the circle of curvature, and its radius is the radius of curvature.

Had B been the vertex of the axis, every intersection on one side of B would have been similar to an intersection on the other, and there would always have been two pairs of roots that are equal; and therefore when three intersections coalesce, a fourth also coalesces, and the contact is said to be still closer.

What has now been shewn with respect to a conic section is true of every curve. When two intersections coalesce, there is a common tangent; when three coalesce, there is an equal curvature, and no other circle can pass between this circle and the curve. There cannot be a coalescence of four intersections, except when the diameter is perpendicular to the ordinates, and those are bisected by the diameter.

Mr Leibnitz, who valued himself for metaphysical refinement, and never fails to claim superiority in this particular, notices the important distinction between a simple contact and this closer union, in a very well written dissertation, published in the *Acta Eruditorum*, July 1686. He calls the contact of equal curvatures an OSCULATION, and the circle of equal curvature the OSCULATING CIRCLE, and delivers several very judicious remarks with the tone of a master and instructor. He also speaks of different degrees or orders of osculation, each of which is infinitely closer than the other, as a thing not remarked by geometers. But Sir Isaac Newton had done all this before. The first twelve propositions of the *Principia* had been read to the Royal Society several years before, and were in the Registers. The *Principia* had received the imprimatur of the Society in July 1686; but was almost printed before that time. In the Scholium to the 11th Lemma, is contained the whole doctrine of contact and osculation; and in the lemma and its corollaries, is crowded a body of doctrine, which has afforded themes for volumes. The author glances with an eagle's eye over the whole prospect, and points out the prominent parts with the most compressed brevity; but with sufficient precision for marking out the more important objects, and particularly the different orders of curvature. This lemma and its corollaries are continually employed in the twelve propositions already mentioned. In 1671 he had written the first draught of his method of fluxions, where this doctrine is systematically treated; and Mr Collins had a copy of it ever since 1676. It is well known that Leibnitz, when in London, had the free perusal of the Society's records, and information at all times by his correspondence with the secretary Oldenburgh and Mr Collins. His conduct respecting the theorems concerning the elliptical motion of the planets, and the resistance of fluids, leave little room to doubt of his having availed himself in like manner of his opportunity of information on this subject. He gives a much better account of the Newtonian doctrine on this subject than in those other instances, it being more suited to his refining and paradoxical disposition. Involution.

In this and another dissertation, he considers more particularly the nature of evolution, and of that osculation which obtains between the evolutrix and the circle described by the evolved radius. He says, that it is equivalent to two simple contacts, each of which is equivalent to two intersections. An osculation produced in the evolution of a curve is therefore equivalent to four intersections. And he advises, with an air of authority, the mathematicians to attend to these remarks, as leading them into the recesses of science. He is mistaken, however; and the listening to him would prevent us from forming a just notion of osculation, and from conceiving with distinctness the singular fact of a circle both touching and cutting a curve in the same point. James Bernoulli lost his friendship, beca... presumed to say that the presence of four intersection... in an osculation is not warranted by the equation expressing those intersections.

Mr Leibnitz was misled by the way in which he had considered the osculation in the evolution of curves. It merits attention. From any point within the space ADFOA (fig. 1.), two perpendiculars may be drawn to the evolutrix A *b d f*; and therefore two circles may be described round that point, each touching the curve. Each contact is the union of two intersections. Therefore, as the centre approaches the evolute, the contacts approach each other, and they unite when the centre reaches the evolute. Therefore the osculation of evolution is equivalent to four intersections.

But when two such circles are described round a point *ε*, so as that both may touch the evolutrix A *a f*, the point *ε* is in the intersection of one evolved radius with the *prolongation* of another. The contact at the extremity *b* of the prolonged radius *b* B is an exterior contact, and the arch of the circle crosses the evolutrix, from without inwards, in some point more remote from A. The contact at the extremity *e* of the radius *ε* E is an interior contact; and if *ε e* be greater than the straight line EA, the arch of this circle crosses the curve, from within outwards, in some point nearer to A. Thus each contact is accompanied by an intersection on the side next the other contact, sometimes beyond it, and sometimes between the contacts. As the contacts approach, the intersections also approach, still retaining their characters as intersections, as the contacts still continue contacts. Also the circle next to A crosses from without inwards, and that next to *f* crosses from

within

[illegible] within outwards. They [illegible] in this character to the last; and when the [illegible] coalesce, the [illegible] obsolete over them [illegible] circumference, still, however, crossing the curve in the same direction as before; that is, without the curve on the side of A, and within it on the side of *f*. The contacts unite as contacts, and the intersections as intersections. Thus it is that the osculating circle both touches and intersects the curve in the same point.

At *f* the osculation is indeed closer than anywhere else. The variation of curvature is less there than anywhere else, because the radius changes more slowly. It is this circumstance that determines the closeness of contact. If a circle osculates a curve, it has the same curvature. If this curvature does not change in the vicinity of the contact, the curve and circle must coincide; and the deviation of the circle (the curvature of which is everywhere the same) from the curve must proceed entirely from the variation of its curvature. This, therefore, is the important circumstance, and is indeed the characteristic of the figure as a curve line; and its other properties, by which the position of its different parts are determined, may be ascertained by means of the *variation* of its curvature, as well as by its relation to co-ordinates. Of this we have a remarkable instance at this very time. The orbit of the newly discovered planet has been ascertained with tolerable precision by means of observations made on its motions for three years. In this time it had not described the 20th part of its orbit; yet the figure of this orbit, the position of its transverse axis, the place and time of its perihelion, were all determined within 100dth part of the truth by the *observed variation* of its curvature. It therefore merits our attention in the close of this article. We know of no author who has treated the subject in so instructive a manner as Mr M'Laurin has done, by exhibiting the theorem which constitutes Newton's 11th lemma in a form which points this out even to the eye (see *M'Laurin's Fluxions*, Chap. xi. § 363, &c.). We earnestly recommend this work to the young geometer, as containing a fund of instruction and agreeable exercise to the mathematical genius, and as greatly superior in perspicuity and in ideas which can be treasured up and recollected, when required, to the greatest part of the elaborate performances of the eminent analysts of later times. By expressing every thing geometrically, the author furnishes us with a sort of picture, which the imagination readily reviews, and which exhibits in a train what mere symbols only give us a momentary glimpse of.

"As, of all right lines which can be drawn through a given point in the arch of a curve, that alone is the tangent which touches the arch so closely that no right line can pass between them; so, of all circles which touch a curve in a given point, that circle alone has the same curvature which touches it so closely that no circle can pass between them. It cannot coincide with the arch of the curve; and therefore the above condition is sufficient for making it equicurve. As the curve separates from the tangent by its flexure or curvature, it separates from the equicurve circle by its *change* of curvature; and as its curvature is greater or less according as it separates more or less from its tangent, so the variation of its curvature is greater or less according as it separates more or less from its equicurve circle. There can be but one equicurve circle at one point of a curve, otherwise any other circle described between them through that point will pass between the curve and the equicurve circle. Involution.

"When two curves touch each other in such a manner that no circle can pass between them, they must have the same curvature; because the arch which touches one of them so closely that no circle can pass between them, must touch the other in like manner. But circles may touch the curve in this manner, and yet there may be indefinite degrees of more or less intimate contact between the curve and its equicurve circle." This is shewn by the ingenious author in a series of propositions, of which a very short abridgment must suffice in this place.

Let any curve EMH (fig. 11.), and a circle ERB, touch a right line ET on the same side at E. Let any right line TK, parallel to the chord EB of the circle, meet the tangent in T, the curve in M, and a curve BKF (which passes through B) in K. Then, if $MT \times TK$ be everywhere equal to TE^2, the curvature of EMH in the point E is the same as that of the circle ERB; and the contact of EM and ER is so much the closer the smaller the angle is which is contained at B between the curve BKF and the equicurve circle BQE.

Let TK meet the circle in R and Q. Then, because $RT \times TQ = TE^2$, it must be $RT \times TQ = MT \times TK$; and $RT : MT = TK : TQ$. The line BKF may have any form. It may cross the circle BQR in B, as in the figure. It may touch it, or touch EB, &c. Let us first consider what situations of the point M correspond with the position of K, in that part of the curve BKF which lies without the circle BRE. Let TK move toward EB, always keeping parallel to it, till it coincide with it, or even pass it. Then, while the point K describes KB, it is evident that since TK is greater than TQ, TM must be less than TR, and the point M must always be found between T and R. The arch ME of the curve must be nearer to the tangent than the arch RE of the circle. If any circle be now described touching TE in E, and cutting off from EB a smaller chord than EB, it is clear that the whole of this segment must be within the segment BRE; therefore this smaller circle does not pass between ERB and the curve EMH. But since we see that the curve lies without the circle, in the vicinity of E, perhaps a greater circle than ERB may pass between it and the curve. A greater circle, touching at E, must cut off a chord greater than EB. Let E*rb* be such a circle, cutting EB in *b*, and TQ in *q*. T*q* is necessarily greater than TQ. For since *b* is beyond B, and the arch BKF lies in the angle QB*b*, the circle E*rq* must cross the curve FKB in some point; suppose F. Then while K is found in the arch FB, the point *q* must be beyond K, or T*q* must be greater than TK. Now $Tr \times Tq = TE^2, = TM \times TQ$. Therefore $TM : Tr = Tq : TQ$. Therefore T*q* being greater than TQ, T*r* must be less than TM, and the point *r* must lie without the curve, and the arch E*r* does not pass between EMH and the circle ERB. In like manner, on the other side of EB, it will appear, that when the curve BK'F falls within the circle which touches EMH in E, and cuts off the chord EB, the arch of the curve corresponding to the arch BK'F, lying within the circle, also lies within the circle. For TK' being less than TQ', TM' is greater than TR', and the curve is within

Involution within the circle. And, by similar reasoning, it is evident that a circle cutting off a greater chord falls without both the circle ERB and the curve, and that a circle less than ERB must necessarily have some part of the curve BKF without it; and therefore TK′ will be greater than Tq', and the corresponding point r' must be without the curve. All circles therefore touching TE in E fall without both ER and EM, or within them both, according as they cut off from EB a chord greater or less than EB, and no circle can pass between them when the rectangle MT × TK is always equal to ET², and the focus of the point K passes through B; that is, ERB is the equicurve circle at E.

This corroborates the several remarks that we have made on the circumstance of a circle touching and cutting a curve in the same point. No other circle can be made to pass between it and the curve, and it therefore has the same curvature. This may therefore be taken as a sufficient indication of the equicurve circle; the character peculiarly assured to it by the nature of evolution. It must be noted, however, that the curve is supposed to have its concavity in the vicinity of the contact turned all the same way. For if the contact be in a point of contrary fluxure, even a straight line will both touch and cut it in that point.

The reader cannot but remark, that MK is always the chord of a circle touching TE in E, and passing through M.

Let Em be another curve, touching TE in E, such, that the conjugate curve kB, which always gives Tm × Tk = TE², also passes through B. Then, by what has now been demonstrated, the two curves EM and Em have the same equicurve circle ERB, and consequently the same curvature in E. Then, because the rectangles RT × TQ, MT × TK, and mT × Tk, are equal, we have Tm : TM = TK : Tk. Therefore if the arch Bk pass between BK and BQ, the curve Em must pass between the curve EM and the circle ER. Em must therefore have a closer contact with ER than EM has with it; and the smaller the angle QBK is which is contained between the curve and its equicurve circle, the closer is the contact of the curve EM and its equicurve circle ER. Thus the length of the chord EB determines the *magnitude* or degree of curvature at E, when compared with another; and the angle contained between the equicurve circle and the conjugate curve BKF determines the closeness of the contact of the curve with its equicurve circle (the angle TEB being supposed the same in both).

It appears, from the process of demonstration, that the curve EMH falls without or within the equicurve circle according as its conjugate curve BKF does. Also, when BKF cuts BQR, HME also cuts it. But if FQB is on the same side of QB on both sides of the intersection B, the curve HME is also on the same side of it on both sides of the contact E. It is also very clear, that the contact or approach to coalescence between the curve and its circle of curvature, is so much the closer as the conjugate curve BKF comes nearer to the adjoining arch of this circle. It must be the closest of all when KB touches QB, and it must be the least so when KB touches EB, or has EB for an assymptote. The space QBK is a sort of magnified picture of the space MER; and we have a sensible proportion of KQ to TK as the representation of the proportion of TM to TR, quantities which are frequently evanescent and insensible. When QBK is a finite angle, that is, when the tangents of BQ and BK do not coincide, the angle QBK can be measured. But no rectilineal angle can be contained as an unit in the curvilineal angle MER. They are incommensurable, or incomparable. Let the curve KB touch the circle QB without cutting it. This angle is equal incomparable with the former QBK; yet it has a counterpart in MER. This must be incomparable with the former in the same manner; for there is the same proportion between the individuals of both pairs. Thus it appears plainly, that there are curvilineal angles incomparable with each other. Yet are they magnitudes of one kind; because the smallest rectilineal angle must certainly contain them both; and one of them contains the other. But, further, there may be indefinite degrees of this coalescence or closeness of contact between a curve and a circle. The first degree is when the same right line touches both. This is a *simple contact*, and may obtain between any curve and any circle. The next is when EMH and ERB have the same curvature, and when the conjugate curve FKB intersects the circle QB in any assignable angle. This is an *osculation*. The third degree of contact, and second of osculation, is when the curve KB touches the circle QB, but not so as to osculate. The fourth degree of contact, and third of osculation, is when KB and QB have the same curvature or osculate in the first degree of osculation. This gradation of more and more intimate contact, or (more properly speaking) of approximation to coalescence, may be continued without end, "*neque novit natura limitem*," the contact of EM and ER being always two degrees closer than that of BK and BQ. Moreover, in each of those classes of contact there may be indefinite degrees. Thus, when EM and ER have the same curvature, the angle QBK admits of indefinite varieties, each of which ascertains a different closeness of contact at E. Also, though the angle QBK should be the same, the contact at E will be so much the closer the greater the chord EB is.

For TR : TM = TK : TQ

Therefore RM : TR = KQ : KT

Or RM : KQ = TR : TK; = TR × TQ : TK × TQ, = TE² : TK × TQ.

Therefore, when TE is given, RM (which is then the measure of the angle of contact) is proportional to KQ directly, and to the rectangle TK × TQ inversely; and when KQ is given, RM is less in proportion as KT × TQ is greater. In the very neighbourhood of E and B, it is plain that KT × TQ is very nearly equal to EB², and therefore ultimately RM : KQ = ET² : EB².

It will greatly assist our conception of this delicate subject, if we view the origin of these degrees of contact as they are generated by the evolution of lines. A thread evolving from a polygon EDCBA (fig. 13.) describes with its extremity a a line $edbga$, consisting of successive arches of circles united in simple contacts. If it evolve from any continuous curve CBA, after having evolved from the lines ED, BC, the arch cb will be united with the circular arch dc by osculation of the first degree. If any other curve FC touch this evolute in a simple contact, and if the two curves FCBA and DCBA are both evolved, they will touch each other in

Involution. a simple osculation in that point where they have the same radius. If FC touches DC in a simple osculation, the evolved curves will touch in an osculation of the second degree; and, in general, the osculation of the two generated curves is a degree closer than that of their evolutes; and in each state of one of the osculations, there is an indefinite variety of the other, according to the length of its radius of curvature. All this is very clear; and shews, that these degrees of contact do not indicate degrees of curvature, one of which infinitely exceeds another; for they are all finite.

The reader will do well to remark, that the magnitude, which is the subject of the above proportions, which is really of the same kind in them all, and considered as susceptible of various degrees and orders of infinitesimals, is not curvature, but lineal extension. It is RM, the subtense of the angle of contact MER. It is the linear separation from the tangent, or from the equicurve circle. It is, however, usually considered as the measure of curvature, or the proportions of this line are given as the proportions of the curvature. This is inaccurate; for curvature is unquestionably a change of direction only. As this line has generally been the interesting object in the refined study of curve lines, especially in the employment of it in the discussions of mechanical philosophy, it has attracted the whole attention, and the language is now appropriated to this consideration. What is called, by the most eminent mathematicians, variation of curvature, is, in fact, variation of the subtense of the angle of contact. But it is necessary always to distinguish them carefully.

Variation of curvature is the remaining object of our attention.

Curvature is uniform in the circle alone. When the curvature of the arch EMH (fig. 11.) decreases as we recede from E, the arch, being less deflected from its primitive direction ET than the arch ER, must separate less from the line ET, or must fall without the arch ER. The more rapidly its curvature decreases, the describing point must be left more without the circle. It must be the contrary, if its curvature had increased from E toward M. It may change its curve equably or unequably. If equably, there must be a certain uniform rate, which would have produced the same final change of direction in a line of the same length, bending it into the uniformly incurvated arch of a circle. It is not so obvious how to estimate a rate of variation of curvature; and authors of eminence have differed in this estimation. Sir Isaac Newton, who was much interested in this discussion, in his studies on universal gravitation, seems to have adopted a measure which best suited his own views; and has been followed by the greater number. He gives a very clear conception of what he means, by stating what he thinks a case of an invariable rate of variation. This is the equiangular spiral, all the arches of which, comprehended in equal angles from the centre, are perfectly similar, although continually varying in curvature. He calls this a curve EQUABLY VARIABLE, and makes its rate of variation (estimated in that sense in which it is uniform) the measure of the rate of variation in all other curves. Let us see in what respect its variation of curvature is constant. It may be described by the evolution of the same spiral in another position (see fig. 6), and the ratio between the radius of the evolute and that of the evolutrix is always the same; or (which amounts to the same thing) the arch of the evolutrix bears to the evolved arch of the evolute a constant ratio. The curvature of the spiral changes more rapidly in the same proportion as the ratio of the evolved arch to the arch of the evolutrix generated by it is greater, or as it cuts the radii in a more acute angle. These arches may be infinitesimal; therefore the fraction $\frac{\text{fluxion of evolute}}{\text{fluxion of evolutrix}}$ expresses the rate of the variation of curvature in this spiral. Now let $abcd$ (fig. 13.) be any other curve, and ABCD its evolute; let p be the centre of curvature at the point B of the evolute, and Bo the evolved arch; draw the radii pB, po, Bm, on; join pm, and draw Bq perpendicular to pm. It is evident that mn and Bo have the same ratio with Bm and Bp; and that these two small arches may be conceived as being portions of the same equiangular spiral (perhaps in another position), of which q is the centre; and that p is in the curve of another of the same. For $qp : q\text{B} = q\text{B} : q\text{M}, = p\text{B} : \text{B}m$, therefore the ratio of these infinitesimal arches mn and Bo will express the rate of variation in any curve. This is evidently equivalent to saying, that the variation of curvature is proportional to the fluxion of the radius of curvature directly, and the fluxion of the curve inversely. For mn and Bo are ultimately as those fluxions, and $\frac{\text{B}o}{mn}$ is equivalent to $\frac{\dot{r}}{\dot{z}}$, where z is the arch of the spiral, and r the evolved radius of the other. Accordingly, this is the enunciation of the INDEX OF VARIATION given by Newton (See Newton's Fluxions, Prob. VI. § 3.). Therefore, what Newton calls a uniform variation of curvature, is not an increase or diminution by equal arithmetical differences, but by equal proportions of the curvature in every point. The variation of curvature in similar points of similar arches is supposed to be the same.

It is evident that this ratio is the same with that of radius to the tangent of the angle pmB, or of 1 to its tabular tangent. The tangent therefore of this angle corresponding to any point of a curve is the measure of the variation of curvature in that point. Now it may be shewn (and it will appear by and bye), that the fluxion of TK in fig. 11. or the ultimate value of KQ, is always $\frac{2}{3}$ds of the fluxion of the radius of curvature. Therefore the tangent of the angle QBK is always $\frac{2}{3}$ds of that of pmB; and therefore the angle QBK, which we have seen to be an index of the closeness of contact, is also the index of the variation of curvature (See *M'Laurin*, § 386.).

Sir Isaac Newton has given specimens of the use of this measure in a variety of geometrical curves, by means of a general expression of $\frac{\dot{r}}{\dot{z}}$. Thus, in the curve ABC (fig. 8.), let AB be — AD $= x$, DB $= y$ BN $= r$, and BE $= p$; we have $\frac{\text{N}n}{\text{B}b} = \frac{\dot{r}}{\dot{z}}$. Now DB : BE $= y : p, = \text{D}d : \text{B}b, = \dot{x} : \dot{z}$. Therefore $\dot{z} = \frac{p\dot{x}}{y}$, and $\frac{\dot{r}}{\dot{z}} = \frac{y\dot{r}}{p\dot{x}}$. Now, in every curve which we can express by an equation, we can obtain all these quantities p, y, r, and z, and can therefore obtain the measure of

Evolution. of the variation of curvature. It is alfo deferves particular notice, that this inveftigation of $\frac{\dot r}{\dot z}$ is equivalent with finding the centre and radius of curvature of the evolute, by which the curve under confideration is generated; or with finding the centre q (fig. 13.) of an equiangular fpiral, which will touch our curve in m, its evolute in B, and the evolute of the evolute in p, if put into different pofitions when neceffary. This leads to very curious fpeculations, for which, however, we have no room. It has been faid, for inftance, that the curvature at the interfection of a cycloid with its bafe is infinitely greater than that of any circle. If the evolution of the cycloid begin from this point, the curvature of its evolutrix will be infinitely greater ftill upon the fame principles; and we fhall have one infinitely greater than this by evolving it. Yet all thefe infinites, multiplied to infinity, are contained in the central point of every equiangular fpiral! In like manner, there are evolutrixes which coincide with a ftraight line, and others of infinitely greater rectitude, and ftill they are curves. Can this have any meaning? And can it be reconciled with the legitimate reafoning from the fame principles, that all thefe curvatures and angles of contact are producible by evolution; and that they may be, and certainly are every day defcribed, by bodies moving in free fpace, and acted on by accelerating forces directed to different bodies?

The parabola (conical) is the moft fimple of all the lines of unequably varying curvature, and becomes a very good ftandard of comparifon. In the parabola ABC (fig. 8.) let the parameter be $2a$. The equation is then $2ax = y^2$; DE $= a$; p, or BE $= \sqrt{a^2+y^2}$ DQ $= a + 2x$ (by what was formerly demonftrated). Moreover, DB : BE = DQ : BN; and BN $= \frac{pa+2px}{a} = r$. Thefe equations give $2a\dot x = 2y\dot y = 2p\dot p$; and $\frac{a\dot p + 2x\dot p + 2p\dot x}{a} = \dot r$. Now making $\dot x = 1$, and reducing the equations, we obtain $\dot y = \frac{a}{y}$; $\dot p = \frac{y\dot y}{p} = \frac{a}{p}$; and $\dot r = \frac{a\dot p + 2x\dot p + 2p}{a}$.

With thefe values of $\dot y, \dot p, \dot r$, we obtain a numerical value of $\frac{y\dot r}{p}$ moft readily. Thus, in order to obtain the index of variation of curvature in the point where the ordinate at the focus cuts the parabola, make $a = 1$. Then $2x = y^2$; $x = \frac{1}{2}$, $y\ (= \sqrt{2x}) = 1$; $\dot y \left(= \frac{a}{y}\right) = 1$; $p\ (= \sqrt{a^2+y^2}) = \sqrt{2}$; $\dot p \left(= \frac{a}{p}\right) = \sqrt{\frac{1}{2}}$, and $\dot r \left(= \frac{a\dot p + 2x\dot p + 2p}{a}\right) = \sqrt{2} \times 3$. Therefore $\frac{y\dot r}{p} = 3$, = the index of variation in the point B when D is the focus of the parabola; that is to fay, the fluxion of the radius of curvature is three times the fluxion of the curve.

The index of variation, where the ordinate is equal to the parameter, is had by making $x = 2$. This gives Involution. $y = 2$; $\dot y = \frac{1}{2}$; $p = \sqrt{5}$; $\dot p = \sqrt{\frac{1}{5}}$, and $\dot r = 3\sqrt{5}$. Wherefore $\frac{y\dot r}{p} = 6$, which is the index of variation. Moreover, fince $\dot p$ and $\dot r$ are in a conftant ratio, it appears that the index of variation of curvature in the parabola is proportional to the ordinate y. It is always $= 6\,\frac{\text{ordinate}}{\text{parameter}}$; and thus, with very little trouble, we can defcribe the evolute of its evolute, *i. e.* of the femicubical parabola.

In like manner, it may be fhewn, that in all the conic fections $\frac{\dot r}{\dot z}$ is always proportional to the rectangle of the ordinate DB and the fubnormal DE, or to DB × DE. In the parabola, whofe equation is $2ax = y^2$, we have $\frac{\dot r}{\dot z} = \frac{3y}{a}$. In an ellipfe, whofe equation is $2ax - bx^2 = y^2$, we have $\frac{\dot r}{\dot z} = \frac{3 - 3b}{a} \times$ DB × DE, and in the hyperbola, whofe equation is $2ax + bx^2$, $\frac{\dot r}{\dot z}$ is $= \frac{2 + 3b}{a} \times$ DB × DE. This ratio, in all the three fections, is always as the tangent of the angle contained between the diameter and the normal at the point of contact. By this we may compare them with a parabola. In the cycloid at the point E (fig. 5.) $\frac{\dot r}{\dot z}$ is = tan. ∠ EKM, &c. &c.

All thefe things may be traced in the obfervations made on fig. 11. and 12. When the angle BEF is a right angle, the angle KBQ indicates it directly, its tangent being always $= \frac{2}{3}\frac{\dot r}{\dot z}$. It is eafy alfo to fee, that when the curve EMH is a parabola, the line BKF is a ftraight line parallel to EF. It is alfo plain, that by the fame fteps that we proved that no circle can pafs between this parabola and its equicurve circle FRB, fo no other parabola can pafs between them. Indeed the fame reafoning will prove that no curve of the fame kind can pafs between any curve and its ofculating circle. In many cafes, it is more eafy to reafon from the curvature of a curve, by comparing it with an equicurve parabola than with an equicurve circle; particularly in treating of the curvilineal motions of bodies in free fpace, actuated by deflecting forces.

If EMH be an ellipfe or hyperbola, BKF is another ellipfe or hyperbola (*M'Laurin*, § 373.)

We have thus endeavoured to introduce our readers into this curious branch of fpeculative geometry. An introduction is all that can be expected from a work of this kind. We have enlarged on particular points, in proportion as we thought that the notions entertained on the fubject were inadequate, or even vague and indiftinct; and we hope that fome may be incited to acquire clearer conceptions by going to the fountain head. We conclude, by recommending to the young geometer the perufal of the Fluxions of Sir Ifaac Newton,

after he has read [illegible]'s Chapter with care. He will probably be surprised and delighted with seeing the whole compressed by a master's hand into such narrow compass with such beautiful perspicuity.

JOAN D' ARC, the maid of Orleans, has been variously characterised; but all now agree, that she was worthy of a better fate than the horrid death she was doomed to die. (See JOAN *d'Arc, Encycl.*). But did she actually die that death? An ingenious writer in the *Monthly Magazine* has proved, we think, that she did not.

The bishop of Beauvais (says he) is accused by all parties of treachery and trick in the conduct of the trial: it was his known propensity to gain his ends by stratagem, craft, manœuvre, fraud, dexterity. He seeks out, and brings forward, such testimony only as relates to ecclesiastical offences, and then hands over the decision to the secular judges, whose clemency he invokes. Joan says to him publicly, "You * *promised* to restore me to the church, and you deliver me to my enemies." The intention of the bishop, then, must have been, that the secular judges, for want of evidence, should see no offence against the state; as the clerical judges, notwithstanding the evidence, had declined to see any against the church. A fatal sentence was, however, pronounced; and the fulfilment of it entrusted to the ecclesiastical authorities. Immediately after the *auto da fe*, one of the executioners ran to two friars, and said, "that he had never been so shocked at any execution, and that the English had built up † a scaffolding of plaster (*un echafaud de platre*) so lofty, that he could not approach the culprit, which must have caused her sufferings to be long and horrid." She was, therefore, by some *unusual* contrivance, kept out of the reach and observation even of the executioners.

Some time after, when public commiseration had succeeded to a vindictive bigotry, a woman appeared at Metz ‡, who declared herself to be Joan of Arc. She was everywhere welcomed with zeal. At Orleans, especially, where Joan was well known, she was received with the honours due to the liberatress of the town. She was acknowledged by both her brothers, Jean and Pierre d'Arc. On their testimony she was married by a gentleman of the house of Amboise, in 1436. At their solicitation her sentence was annulled in 1456. The Parisians, indeed, long remained incredulous: they must else have punished those ecclesiastics, whose humanity, perhaps, conspired with the bishop of Beauvais to withdraw her from real execution down a central chimney of brick and mortar; or, as the executioner called it, a scaffolding of plaster. The king, for the woman seems to have shunned no confrontation, is stated to have received her with these words: "*Pucelle, m'amie, soyez la très bien revenue, au nom de Dieu.*" She is then said to have communicated to him, kneeling, the artifice practised. Can this woman be an impostor? Our author thinks not, and appeals to Voltaire, who, in his prose works, seems willing to allow that she was not, as is too commonly imagined, one of those half-insane enthusiasts, employed as tools to work upon the vulgar; whom the one party endeavoured to cry up as a prophetess, and the other to cry down as a witch; but that she was a real heroine, superior to vulgar prejudice, and no less remarkable by force of mind than for a courage and strength unusual in her sex. This opinion is certainly countenanced by her behaviour in adversity, and during her trial, which was firm without insolence, and exalted without affectation.

* *Villaret Histoire de France*, tom. xv. p. 72.

† *Pasquier Histoire d'Orleans*, l. v. vi.

‡ *Histoire de la Pucelle par l'Abbe Lenglet*. See also *Melanges Curieux Menstrelet*; and the manuscript authorities cited by the continuator of Velly.

JONES (Sir William), who was styled by Johnson the most enlightened of men, was the son of William Jones, Esq; one of the last of those genuine mathematicians, admirers, and contemporaries of Newton, who cultivated and improved the sciences in the present century. Our author was born on the 28th of September 1746, and received his education at Harrow school, under the care of Dr Robert Sumner, whom he has celebrated in an eulogium which will out-last brass or marble. We are told that he was a class fellow with Dr Parr, and at a very early age displayed talents which gave his tutor the most promising expectations, and which have since been amply justified. From Harrow he was sent to University college, Oxford, where the rapidity and elegance of his literary acquisitions excited general admiration; while a temper, ardently generous, and morals perfectly irreproachable, procured him testimonies of the most valuable esteem. The grateful affection which he always cherished for that venerable seat of learning, did as much honour to his sensibility, as Oxford herself has received by enrolling him among the number of her sons.

In the twenty-third year of his age he travelled through France, and resided some time at Nice, where he employed himself very differently from most other young men who make what is called the tour of Europe. *Man*, and the influence of various forms of *government*, were the principal objects of his investigation; and in applying the result of his inquiries to the state of his own country, he mingled the solicitudes of the Patriot with the honest partialities of an Englishman.

Mr Jones's first literary work was a translation into French of a Persian manuscript, entitled "*Histoire de Nadir Shah, connu sous le nom de Thahmas Kuli Khan, Empereur de Perse*," in two vols. 4to; the history of which performance we shall give in his own words: "A great northern monarch, who visited this country a few years ago, under the name of the Prince of Travendal, brought with him an eastern manuscript, containing the life of Nadir Shah, the late sovereign of Persia, which he was desirous of having translated in England. The secretary of state, with whom the Danish minister had conversed upon the subject, sent the volume to me, requesting me to give a literal translation of it in the French language; but I wholly declined the task, alledging for my excuse the length of the book, the dryness of the subject, the difficulty of the style, and chiefly my want both of leisure and ability to enter upon an undertaking so fruitless and so laborious. I mentioned, however, a gentleman, with whom I had not then the pleasure of being acquainted, but who had distinguished himself by a translation of a Persian history, and was far abler than myself to satisfy the king of Denmark's expectations. The learned writer, who had other works upon his hands, excused himself on the account of his many engagements; and the application to me was renewed. It was hinted, that my compliance would be of no small advantage to me at my entrance into life; that it would procure me some mark of distinction which might be pleasing to me; and, above all, that it would be a reflection

Jones. tion upon this country, if the king should be obliged to carry the manuscript into France. Incited by these motives, and principally by the last of them, unwilling to be thought churlish or morose, and eager for the bubble reputation, I undertook the work, and sent a specimen of it to his Danish Majesty; who returned his approbation of the style and method, but desired that the whole translation might be perfectly literal, and the oriental images accurately preserved. The task would have been far easier to me, had I been directed to finish it in Latin; for the acquisition of a French style was infinitely more tedious; and it was necessary to have every chapter corrected by a native of France, before it could be offered to the discerning eye of the public, since in every language there are certain peculiarities of idiom, and nice shades of meaning, which a foreigner can never learn to perfection. But the work, how arduous and unpleasing soever, was completed in a year, not without repeated hints from the secretary's office that it was expected with great impatience by the Court of Denmark." The translation of the History of Nadir Shah was published in the summer of the year 1770, at the expence of the translator; and forty copies upon large paper were sent to Copenhagen; one of them bound with uncommon elegance for the king himself, and the others as presents to his courtiers*.

* Preface to the History of Nadir Shah, 1773.

What marks of distinction our author received, or what fruits he reaped for his labour, he has not thought proper to disclose; but if any dependence is to be placed on common fame, the reward bestowed upon him for this laborious task consisted only in the thanks of his Danish Majesty, and the honour of being enrolled in the Royal Society of Copenhagen. That distinction was indeed accompanied with a letter, recommending the learned translator to the patronage of his own sovereign; but, in the interim, his friend Lord Dartmouth, who was to have delivered it, had resigned his office of secretary of state, and the letter, we are told, was never presented.

There is reason to think, that this early and severe disappointment made a deep impression on his mind, and induced him to renounce the muses for a time, and to apply himself with assiduity to the study of jurisprudence. This we think apparent, from the style in which he writes of his return from the continent, and of the death of his beloved preceptor Dr Sumner.

"When I left Nice, (says he) where I had resided near seven months, and after traversing almost all France, returned to England, I most ardently desired to pass several years more in the study of polite literature; as then, I thought, I might enter into public life, to which my ambition had always prompted me, more mature and prepared: but with this fruit of my leisure, either fortune, or rather Providence, the disposer of all human events, would not indulge my sloth; for on a sudden, I was obliged to quit that very literature to which, from my childhood, I had applied myself; and he who had been the encourager and assistant of my studies, who had instructed, taught, formed me such as I was, or if I am any thing at all, Robert Sumner, within a year after my return, was snatched away by an untimely death (A)."

In 1771 Mr Jones published *Dissertation sur la Literature Orientale*, 8vo, and this was followed by *Lettre à Monsieur A** Du P****, dans laquelle est compris l'Examen de sa Traduction des Livres attribués à Zoroastre*, 8vo. The dissertation offered a favourable specimen of the author's abilities as a linguist and as a critic; and the letter contained a spirited vindication of the university of Oxford, from the very scurrilous reproaches, in which its incompetency in Oriental literature was asserted by the illiberal translator of the supposed works of the Persian philosopher.

In the same year he gave to the public, "A Grammar of the Persian language," 4to, and at the same time proposed to republish Meninski's Dictionary, with improvements from *De Labrosse's Gazophylacium Linguæ Persarum*, and to add in their proper place an Appendix subjoined to Gehanaguire's Persic Dictionary. The Grammar has been found extremely useful, and has

(A) As a specimen of our author's latinity, we subjoin the epitaph on Dr Sumner, which is affixed to the wall of the south transept of Harrow church.

H. S. E.
ROBERTUS SUMNER, S. T. P.
Collegii Regalis apud Cantab. olim Socius,
Scholæ Harroviensis haud ita pridem Archididascalus.
Fuit hoc præstantissimo Viro
Ingenium naturâ peracre, optimarum disciplinis artium sedulo
Excultum, usu diuturno confirmatum, & quodammodo subactum.
Nemo enim aut in reconditis sapientiæ studiis illo subtilior extitit,
Aut humanioribus literis limatior: nemini fere vel felicius
Contigit judicii acumen, vel uberior eruditionis copia.
Egregiis hisce cum dotibus naturæ, tum doctrinæ subsidiis,
Insuper accedebat in scriptis mira ac prope perfecta eloquentia.
In sermone facetiarum lepor plane Atticus, & gravitate suaviter
Aspera urbanitas; in moribus singularis quædam integritas & fides;
Vitæ denique ratio constans sibi, & ad virtutis normam diligenter severeque,
Exculta. Omnibus qui vel amico essent eo, vel magistro usi, doctrinæ,
Ingenii, virtutis triste reliquit desiderium, subitâ, eheu! atque immaturâ
Morte correptus prid. Id. Sept. A. D.
1771, Æt. 41.

has been repeated f[illegible] times that the design of the Dictionary, tho[illegible] an object of [illegible]tional [illegible]tance for want of [illegible]e encouragement was obliged to be laid aside.

In 1772 he published "Poems; consisting chiefly of Translations from the Asiatic Languages. To which are added two Essays; 1. On the Poetry of the Eastern Nations. 2. On the Arts commonly called Imitative," 8vo, which in 1777 he republished with the addition of some Latin Poems, every way worthy of their author. On the 18th June 1773, he took the degree of Master of Arts, and the same year published "The History of the Life of Nadir Shah, King of Persia. Extracted from an Eastern Manuscript, which was translated into French by order of his Majesty the King of Denmark. With an Introduction, containing, 1. A Description of Asia according to the Oriental Geographers. 2. A short History of Persia from the earliest Times to the present Century: And an Appendix, consisting of an Essay on Asiatic Poetry, and the History of the Persian Language. To which are added Pieces relative to the French Translation," 8vo. Our author having at this period determined to study the law as a profession, and to relinquish every other pursuit, our readers will not be displeased with the following extract, relating to this resolution, which concludes the preface to the history now under consideration:

"To conclude; if any essential mistakes be detected in this whole performance, the reader will excuse them, when he reflects upon the great variety of dark and intricate points which are discussed in it; and if the obscurity of the subject be not a sufficient plea for the errors which may be discovered in the work, let it be considered, to use the words of Pope in the preface to his juvenile poems, that there are very few things in this collection which were not written under the age of five-and-twenty: most of them indeed were composed in the intervals of my leisure in the South of France, before I had applied myself to a study of a very different nature, which it is now my resolution to make the sole object of my life. Whatever then be the fate of this production, I shall never be tempted to vindicate any part of it which may be thought exceptionable; but shall gladly resign my own opinions, for the sake of embracing others, which may seem more probable; being persuaded, that nothing is more laudable than the love of truth, nothing more odious than the obstinacy of persisting in error. Nor shall I easily be induced, when I have disburdened myself of two other pieces which are now in the press, to begin any other work of the literary kind; but shall confine myself wholly to that branch of knowledge in which it is my chief ambition to excel. It is a painful consideration, that the profession of literature, by far the most laborious of any, leads to no real benefit or true glory whatsoever. Poetry, science, letters, when they are not made the sole business of life, may become its ornaments in prosperity, and its most pleasing consolation in a change of fortune; but if a man addicts himself entirely to learning, and hopes by that, either to raise a family, or to acquire, what so many wish for, and so few ever attain, an honourable retirement in his declining age, he will find, when it is too late, that he has mistaken his path; that other labours, other studies, are necessary; and that unless he can assert his own independence in active life, it will avail him little to be favoured by the learned, esteemed by the eminent, or commended even by kings. It is [illegible] on the other hand, that no external advantage can make amends for the loss of virtue and integrity which alone give a perfect comfort to him who possesses them. Let a man, therefore, who wishes to enjoy, what no fortune or honour can bestow, the blessing of self approbation, aspire to the glory given to Pericles by a celebrated historian, of being acquainted with all useful knowledge, of expressing what he knows with copiousness and freedom, of loving his friends and country, and of disdaining the mean pursuits of lucre and interest: this is the only career on which an honest man ought to enter, or from which he can hope to gain any solid happiness." Jones.

The next year he published *Poeseos Asiaticæ Commentariorum Libri Sex, cum Appendice; subjicitur Limon, seu Miscellaneorum Liber*, 8vo; and pursuing his purpose of applying to the study of the law, we hear no more of him from the press (except the new edition of his Poems), until the year 1779. In this interval he was called to the bar, and attended Westminster-hall and the Oxford circuit, where he obtained but little business. He was however appointed a commissioner of bankrupts by Lord Bathurst, who is supposed to have intended to exert his interest to procure his nomination to the bench in the East Indies.

He published in this year, "The speeches of Isæus, in causes concerning the law of succession to property at Athens; with a preparatory discourse, notes critical and historical, and a Commentary, 4to." In this valuable work, the talents of the scholar, the critic, and the lawyer, combine to elucidate a very important part of jurisprudence; for, "though deep researches into the legal antiquities of *Greece* and *Rome* (as he observes in his Commentary) are of greater use to scholars and contemplative persons, than to lawyers and men of business; though Bracton and Lyttleton, Coke and Rolle, are the proper objects of our study; yet the ablest advocates, and wisest judges, have frequently embellished their arguments with learned allusions to antient cases; and such allusions, it must be allowed, are often useful, always ornamental; and, when they are introduced without pedantry, never fail to please." The work was dedicated in a style of respectful gratitude to his patron Lord Bathurst.

In the year 1780, we find our author a candidate to represent in parliament the university of Oxford. He had for some time resided but little in the university, and therefore laboured under some disadvantages; but he did not meanly court the support of any man. In a paper, which was circulated on that occasion, his friends, who were numerous, declare, that they have "neither openly solicited, nor intend openly to solicit, votes for Mr Jones within the University itself, because he will never become the instrument of disturbing the calm seat of the Muses, by consenting to any such solicitation for himself or for any man whatever. His own applications have been, are, and will be, confined to those only who have professed a regard for him, *and who have no votes themselves*: the Masters of Arts in a great university, whose prerogative is cool reason and impartial judgment, must never be placed on a level with the voters of a borough, or the freeholders of a county.

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county. Even in proceeding thus far, he does not set the example, but follows it; and his friends would never have printed any paper, if they had not thought themselves justified by the conduct of others.

"For the first and the last time, they beg leave to suggest, that no exertions must be spared by those who, either personally or by reputation, approve the character of Mr Jones; into which, both literary and political, as well as moral, his friends desire and demand the strictest scrutiny. For his university he began early to provoke, and possibly to incur, the displeasure of great and powerful men: For his university he entered the lists with a foul-mouthed and arrogant Frenchman, who had attacked Oxford in three large volumes of misrepresentation and scurrility: For his university he resigned, for a whole year, his favourite studies and pursuits, to save Oxford the discredit of not having one of her sons ready to translate a tedious Persian manuscript. To Oxford, in short, he is known to be attached by the strongest possible ties; and only regrets the necessity of absenting himself from the place in which of all others he most delights, until the event of the present competition shall either convince him that he has toiled in vain as a man of letters, or shall confer on him the greatest reward to which he can aspire. The unavoidable disadvantage of being so late proposed, and the respectable support with which he is now honoured, will secure him in all events from the least disgrace." The application was unsuccessful, chiefly because his own college had fixed upon another candidate, from a persuasion that the immediate appointment of Mr Jones to a seat, then vacant on the bench of judges in India, was morally certain.

The riots of that year gave occasion to another publication of our author, entitled, "An Inquiry into the legal Mode of suppressing Riots; with a constitutional Plan of future Defence," 8vo; and in 1781 he published "An Essay on the Law of Bailments," 8vo, a very masterly treatise, which did great honour to his legal abilities. In this last work he inculcates the necessity of deeply exploring the grounds of the common law; and speaking of Blackstone, (he says) "his commentaries are the most correct and beautiful outline that ever was exhibited of any human science; but they alone will no more form a lawyer, than a general map of the world, how accurately and elegantly soever it may be delineated, will make a geographer."

In this year he likewise recalled his muse in an Ode on the nuptials of Lord Viscount Althorpe, who had been his pupil, to Miss Lavinia Bingham. This beautiful little poem is preserved in the European Magazine for January 1785, and we think in other periodical publications.

From many circumstances which might be collected together, it would appear that our author at this juncture did not coincide in opinion with those who had the direction of government, nor did he approve the measures at that period adopted.—With these sentiments he seems to have been selected as a proper person to be introduced as a member of the Constitutional Society. Could he have foreseen the degeneracy of such associations, there is reason to believe that he would have declined what he condescended to accept as an honour; for though an ardent friend to liberty, he was an enemy to theoretical innovation, and declares in a letter to the secretary, that by the term constitution he understands "the great system of public, in contradistinction to private and criminal law, which comprises all those articles which Blackstone arranges, in his first volume, under the rights of persons, and of which he gives a perspicuous analysis. Whatever then relates to the rights of persons, either absolute rights, as the enjoyment of liberty, security, and property, or relative, that is, in the public relations of magistrates and people, makes a part of that majestic whole, which we properly call the constitution. This constitutional or public law is partly unwritten, and grounded upon immemorial usage, and partly written or enacted by the legislative power; but the unwritten, or common law, contains the true spirit of our constitution: the written has often most unjustifiably altered the form of it; the common law is the collected wisdom of many centuries, having been used and approved by successive generations; but the statutes frequently contain the whims of a few leading men, and sometimes of the mere individuals employed to draw them."

In 1782 he published "The Mahomedan Law of Succession to the Property of Intestates, in Arabic, with a verbal Translation and explanatory Notes," 4to.

At length the post of one of the judges in the East Indies, which had been kept vacant five years, was determined upon being filled up; and our author, on the 4th March 1783, was appointed to that station, and on the 20th received the honour of knighthood. On the 8th of April he married Miss Shipley, eldest daughter of the Bishop of St Asaph, and almost immediately embarked for the Indies. He had previously published "The Moallakat; or, Seven Arabian Poems, which were suspended on the Temple at Mecca, with a Translation and Arguments." 4to. To this it was intended to add a preliminary discourse and notes.—The former to comprise observations on the antiquity of the Arabian language and letters; on the dialects and characters of Himyar and Koraish, with accounts of some Himyarick poets; on the manners of the Arabs in the age immediately preceding that of Mahomed; on the temple at Mecca, and the Moallakat, or pieces of poetry suspended on its walls or gate; lastly, on the lives of the Seven Poets, with a critical history of their works, and the various copies or editions of them preserved in Europe, Asia, and Africa. The latter to contain authorities and reasons for the translation of controverted passages; to elucidate all the obscure couplets, and exhibit or propose amendments of the text; to direct the reader's attention to particular beauties, or point out remarkable defects; and to throw light on the images, figures, and allusions of the Arabian poets, by citations either from writers of their own country, or from such of our European travellers as best illustrate the ideas and customs of Eastern nations. This discourse and the notes have not yet appeared. At his departure for the eastern world, he left, in manuscript, with his brother-in-law the Dean of St Asaph, a little tract, entitled "The Principles of Government, in a Dialogue between a Scholar and a Peasant." This celebrated dialogue being afterwards published by the Dean, and widely circulated by the society for constitutional information, the Dean was

 prosecuted

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prosecuted for publishing a libel, and, if our memory deceives us not, was found guilty.

Sir William Jones now dropt for ever all concern in party politics, and applied himself to pursuits more worthy of his talents. During his voyage to India, he conceived the idea of the Asiatic Society, of which an account has been given under the title Societies (*Encycl.*), and of whose researches five volumes, replete with much curious information, are now before the public. But ardently as his mind was attached to general literature and science he was by no means inattentive to the professional duties of his high station. He had indeed, to use his own expression, an "undissembled fondness for the study of jurisprudence *;" and in the character of a judge, displayed the profound knowledge and irreproachable integrity, which, before his promotion, pervaded his reasonings as a lawyer, and governed his conduct as a man. Unfortunately the intense ardour of application, which produced his frequent contributions to the stock of human knowledge, added to the unfavourable influence of the climate, greatly impaired his health. On this account, after a residence of about fifteen years in India, he made preparations for returning to England; but death interposed; and this illustrious ornament of science and virtue was taken from the world on the 27th of April 1794, in the 48th year of his age. "It is to the shame of scepticism (as one of his biographers well observes), to the encouragement of hope, and to the honour of genius, that this great man was a sincere believer in the doctrines of Christianity, and that he was found in his closet in the attitude of addressing his prayer to God." We shall give his character as it was drawn by Sir John Shore, Baronet, (now Lord Teignmouth) in a discourse delivered at a meeting of the Asiatic Society, held on the 22d of May 1794.

"His capacity for the acquisition of languages has never been excelled. In Greek and Roman literature, his early proficiency was the subject of admiration and applause; and knowledge of whatever nature, once obtained by him, was ever afterwards progressive. The more elegant dialects of modern Europe, the French, the Spanish, and Italian, he spoke and wrote with the greatest fluency and precision; and the German and Portuguese were familiar to him. At an early period of life his application to Oriental literature commenced; he studied the Hebrew with ease and success; and many of the most learned Asiatics have the candour to avow, that his knowledge of Arabic and Persian was as accurate and extensive as their own; he was also conversant in the Turkish idiom, and the Chinese had even attracted his notice so far as to induce him to learn the radical characters of that language, with a view perhaps to farther improvements. It was to be expected, after his arrival in India, that he would eagerly embrace the opportunity of making himself master of the Sanscrit; and the most enlightened professors of the doctrines of Brahma confess with pride, delight, and surprise, that his knowledge of their sacred dialect was most critically correct and profound. The Pandits, who were in the habit of attending him, could not, after his death, suppress their tears for his loss, nor find terms to express their admiration at the wonderful progress he had made in their sciences.

"Before the expiration of his twenty-second year, he had completed his Commentaries on the Poetry of the Asiatics, although a considerable time afterwards elapsed before their publication; and this work, if no other monument of his labours existed, would at once furnish proofs of his consummate skill in the Oriental dialects, of his proficiency in those of Rome and Greece, of taste and erudition far beyond his years, and of talents and application without example.

"But the judgment of Sir William Jones was too discerning to consider language in any other light than as the key of science, and he would have despised the reputation of a mere linguist. Knowledge and truth were the objects of all his studies, and his ambition was to be useful to mankind; with these views he extended his researches to all languages, nations, and times.

"Such were the motives that induced him to propose to the government of India, what he justly denominated a work of national utility and importance, the compilation of a copious Digest of Hindu and Mahomedan Law, from Sanscrit and Arabic originals, with an offer of his services to superintend the compilation, and with a promise to translate it. He had foreseen, previous to his departure from Europe, that without the aid of such a work, the wise and benevolent intentions of the legislature of Great Britain, in leaving to a certain extent the natives of these provinces in possession of their own laws, could not be completely fulfilled; and his experience, after a short residence in India, confirmed what his sagacity had anticipated, that without principles to refer to, in a language familiar to the judges of the courts, adjudications amongst the natives must too often be subject to an uncertain and erroneous exposition, or wilful misinterpretation of their laws.

"To the superintendance of this work, which was immediately undertaken at his suggestion, he assiduously devoted those hours which he could spare from his professional duties. After tracing the plan of the Digest, he prescribed its arrangement and mode of execution, and selected from the most learned Hindus and Mahomedans fit persons for the task of compiling it: flattered by his attention, and encouraged by his applause, the Pandits prosecuted their labours with chearful zeal to a satisfactory conclusion. The Molavees have also nearly finished their portion of the work; but we must ever regret, that the promised translation, as well as the meditated preliminary dissertation, have been frustrated by that decree, which so often intercepts the performance of human purposes.

"During the course of this compilation, and as auxiliary to it, he was led to study the works of Menu, reputed by the Hindus to be the oldest and holiest of legislators; and finding them to comprise a system of religious and civil duties, and of law in all its branches, so comprehensive and minutely exact, that it might be considered as the Institutes of Hindu Law, he presented a translation of them to the government of Bengal. During the same period, deeming no labour excessive or superfluous that tended in any respect to promote the welfare or happiness of mankind, he gave the public an English version of the Arabic Text of the Sirajiyah or Mahomedan Law of Inheritance, with a Commentary. He had already (as has been observed) published in England a translation of a tract on the same subject by another Mahomedan lawyer, containing, as his own words express, 'a lively and elegant Epitome of the Law of Inheritance of Zaid.'

"To

"To these learned and important works, so far out of the road of amusement, nothing could have engaged his application but that desire which he ever professed, of rendering his knowledge useful to his nation, and beneficial to the inhabitants of these provinces.

"I should scarcely (continues Lord Teignmouth) think it of importance to mention, that he did not disdain the office of editor of a Sanscrit and Persian work, if it did not afford me an opportunity of adding, that the latter was published at his own expence, and was sold for the benefit of insolvent debtors. A similar application was made of the produce of Sirajiyah."

But nothing exhibits the large grasp of Sir William Jones's mind in so striking a point of view as a paper in his own hand-writing, which came into Lord Teignmouth's possession after his death. It was intitled DESIDERATA, and proposed for investigation the following subjects relating to the eastern world.

India.—1. The ancient geography of India, &c. from the Puranas. 2. A botanical description of Indian plants, from the Cosha, &c. 3. A grammar of the Sanscrit language, from Panini, &c. 4. A dictionary of the Sanscrit language, from the 32 original vocabularies and Niructi. 5. On the ancient music of the Indians. 6. On the medical substances of India, and the Indian art of medicine. 7. On the philosophy of the ancient Indians. 8. A translation of the Veda. 9. On ancient Indian geometry, astronomy, and algebra. 10. A translation of the Puranas. 11. A translation of the Mahabbara and Ramayan. 12. On the Indian theatre, &c. &c. 13. On the Indian constellations, with their mythology, from the Puranas. 14. The history of India before the Madomedan conquest, from the Sanscrit Cashmir Histories.

Arabia.—15. The history of Arabia before Mahomed. 16. A translation of the Hamasa. 17. A translation of Hariri. 18. A translation of the Facabatul Khulafa. Of the Cafiah.

Persia.—19. The history of Persia, from authorities in Sanscrit, Arabic, Greek, Turkish, Persian ancient and modern, Firdausi's Khosrau nama. 20. The five poems of Nizami, translated in prose. 21. A dictionary of pure Persian Je changire.

China.—22. A translation of Shi-cing. 23. The text of Can-fu-tsu, verbally translated.

Tartary.—24. A history of the Tartar nations, chiefly of the Moguls and Othmans, from the Turkish and Persian.

"We are not authorised (says his Lordship) to conclude, that he had himself formed a determination to complete the works which his genius and knowledge had thus sketched; the task seems to require a period beyond the probable duration of any human life; but we, who had the happiness to know Sir William Jones; who were witnesses of his indefatigable perseverance in the pursuit of knowledge, and of his ardour to accomplish whatever he deemed important; who saw the extent of his intellectual powers, his wonderful attainments in literature and science, and the facility with which all his compositions were made—cannot doubt, if it had pleased Providence to protract the date of his existence, that he would have ably executed much of what he had so extensively planned."

We have already enumerated attainments and works which, from their diversity and extent, seem far beyond the capacity of the most enlarged minds; but the catalogue may yet be augmented. To a proficiency in the languages of Greece, Rome, and Asia, he added the knowledge of the philosophy of those countries, and of every thing curious and valuable that had been taught in them. The doctrines of the Academy, the Lyceum, or the Portico, were not more familiar to him than the tenets of the Vedas, the mysticism of the Sufis, or the religion of the ancient Persians; and whilst, with a kindred genius, he perused with rapture the heroic, lyric, or moral compositions of the most renowned poets of Greece, Rome, and Asia, he could turn with equal delight and knowledge to the sublime speculations or mathematical calculations of Barrow and Newton. With them also he professed his conviction of the truth of the Christian religion; and he justly deemed it no inconsiderable advantage, that his researches had corroborated the multiplied evidence of Revelation, by confirming the Mosaic account of the primitive world.

In his eighth anniversary discourse to the Asiatic Society, he thus expresses himself: "Theological inquiries are no part of my present subject; but I cannot refrain from adding, that the collection of tracts which we call, from their excellence, the Scriptures, contain, independently of a divine origin, more true sublimity, more exquisite beauty, purer morality, more important history, and finer strains both of poetry and eloquence, than could be collected within the same compass from all other books that were ever composed in any age, or any idiom. The two parts, of which the Scriptures consist, are connected by a chain of compositions, which bear no resemblance in form or style to any that can be produced from the stores of Grecian, Indian, Persian, or even Arabian learning; the antiquity of these compositions no man doubts, and the unstrained application of them to events long subsequent to their publication, is a solid ground of belief that they were genuine predictions; and consequently inspired."

There were, in truth, few sciences in which he had not acquired considerable proficiency; in most, his knowledge was profound. The theory of music was familiar to him; nor had he neglected to make himself acquainted with the interesting discoveries lately made in chemistry; "and I have heard him (says Lord Teignmouth) assert, that his admiration of the structure of the human frame had induced him to attend for a season to a course of anatomical lectures, delivered by his friend the celebrated Hunter."

His last and favourite pursuit was the study of botany, which he originally began under the confinement of a severe and lingering disorder, which with most minds would have proved a disqualification from any application. It constituted the principal amusement of his leisure hours. In the arrangements of Linnæus, he discovered system, truth, and science, which never failed to captivate and engage his attention; and from the proofs which he has exhibited of his progress in botany, we may conclude that he would have extended the discoveries in that science.

It cannot be deemed useless or superfluous to inquire by what arts or method he was enabled to attain to a degree of knowledge almost universal, and apparently beyond the powers of man, during a life little exceeding 47 years.

The faculties of his mind, by nature vigorous, were improved

in pro[illegible] and exce[illegible] memory, by habitual practice, had acquired a capacity of retaining whatever had once been impressed upon it. To an unextinguished ardour for universal knowledge, he joined a perseverance in the pursuit of it which subdued all obstacles; his studies began with the dawn, and, during the intermissions of professional duties, were continued throughout the day; reflection and meditation strengthened and confirmed what industry and investigation had accumulated. It was a fixed principle with him, from which he never voluntarily deviated, not to be deterred by any difficulties that were furmountable from profecuting to a fuccefsful termination what he had once deliberately undertaken.

But what appeared more particularly to have enabled him to employ his talents fo much to his own and the public advantage, was the regular allotment of his time, and a fcrupulous adherence to the diftribution which he had fixed; hence all his ftudies were purfued without interruption or confufion. He collected information, too, from every quarter; juftly concluding, that fomething might be learned from the illiterate, to whom he liftened with the utmoft candour and complacency.

Lord Teignmouth, addreffing himfelf to the Afiatic Society, fays, "Of the private and focial virtues of our lamented Prefident, our hearts are the beft records. To you who knew him, it cannot be neceffary for me to expatiate on the independence of his integrity, his humanity, probity, or benevolence, which every living creature participated; on the affability of his converfation and manners, or his modeft, unaffuming deportment: nor need I remark, that he was totally free from pedantry, as well as from arrogance and felf-fufficiency, which fometimes accompany and difgrace the greateft abilities. His prefence was the delight of every fociety, which his converfation exhilarated and improved; and the public have not only to lament the lofs of his talents and abilities, but that of his example.

"To him, as the founder of our inftitution, and whilft he lived its firmeft fupport, our reverence is more particularly due. Inftructed, animated, and encouraged by him, genius was called forth into exertion, and modeft merit was excited to diftinguifh itfelf. Anxious for the reputation of the Society, he was indefatigable in his own endeavours to promote it, whilft he cheerfully affifted thofe of others. In lofing him, we have not only been deprived of our brighteft ornament, but of the guide and patron, on whofe inftructions, judgement, and candour, we could implicitly rely." Though thefe are the fentiments, not only of Lord Teignmouth, but, we believe, of every man of letters, we truft there is ftill left in Bengal a fufficient love of letters and of fcience to carry on the plan which was formed by the genius of Sir William Jones.

JONESIA, is a very handfome middling-fized ramous tree, found in gardens about Calcutta. In the Sanfcrit it is called *As'oca*, and in the Bengalefe *Ruffock*; but the name Jonefia was given to it by the Afiatic Society, who confecrated it to the memory of their firft prefident Sir William Jones. It is thus defcribed by Dr Roxburgh, a member of that fociety:

"*Calyx*, two leaved, corol, one petaled, piftil-bearing; bafe of the tube impervious; ftamens long, afcending, inferted into the margin of a glandulous nectarial ring, which crowns the mouth of the tube, the uppermoft two of which more diftant; ftyle declining. *Legume* turgid. *Trunk* erect, though not very ftraight. *Bark* dark brown, pretty fmooth. *Branches* numerous, fpreading in every direction, fo as to form a moft elegant fhady head. *Leaves* alternate, abruptly feathered, feffile, generally more than a foot long; when young pendulous and coloured. *Leaflets* oppofite, from four to fix pair, the lowermoft broad lanced, the upper lanced; fmooth, fhining, firm, a little waved, from four to eight inches long. *Petiole* common, round, and fmooth. *Stipule* axillary, folitary; in fact a procefs from the bafe of the common petiole, as in many of the graffes and monandrifts, &c. *Umbels* terminal and axillary; between the ftipule and branchlet, globular, crowded, fubfeffile, erect. *Bracts*, a fmall hearted one under each divifion of the umbel. *Peduncle* and pedicles fmooth, coloured. *Flowers* very numerous, pretty large; when they firft expand they are of a beautiful orange colour, gradually changing to red, forming a variety of lovely fhades; fragrant during the night. *Calyx* perianth, below two-leaved, leaflets fmall, nearly oppofite, coloured, hearted, bracte like, marking the termination of the pedicel, or beginning of the tube of the corol. *Corol* one petalled, funnel-form; tube flightly incurved, firm, and flefhy, tapering towards the bafe (club funnel-fhaped) and there impervious; border four parted; divifion fpreading, fuborbicular; margins moft flightly woolly: one third the length of the tube. *Nectary*, a ftimeniferous and piftiliferous ring crowns the mouth of the tube. *Stamens*, filaments generally feven; and feven muft, I think, be the natural number; viz. three on each fide, and one below, above a vacancy, as if the place of an eighth filament, and is occupied on its infide by the piftil; they are equal, diftinct, afcending, from three to four times longer than the border of the corol. *Anthers* uniform, fmall, incumbent. *Piftil*, germ oblong, pediceled; pedicel inferted into the infide of the nectary, immediately below the vacant fpace already mentioned; ftyle nearly as long as the ftamens, declining; ftigma fimple. *Pericarp*, legume fcimeter-formed, turgid, outfide reticulated, otherwife pretty fmooth; from fix to ten inches long, and about two broad. *Seeds* generally from four to eight, fmooth; grey, fize of a large chefnut."

Jonefia, Jooth.

The Jonefia flowers at the beginning of the hot feafon, and its feeds ripen during the rains. The plants and feeds were originally brought to Calcutta from the interior parts of the country, where it is indigenous. *N. B.* Many of the flowers have only the rudiment of a piftil. In Plate XXX. A is a branchlet of the natural fize. B, A fingle flower a little magnified; *a a* the calyx. C, A fection of the fame, exhibiting four of the ftamens, 1 1 1 1 the piftil 2, and how far the tube is perforated. D, A fimilar fection of one of the abortive flowers; 3 is the abortive piftil. E, The ripe legume opening near the bafe, natural fize. *Note*, The fpace between the *b* and *c* marks the original tube of the coral. F, One of the feeds, natural fize. G, The bafe of the common petiole, with its ftipule; *a a*, the petioles of the lower pair of leaflets.

JOOTSI-SIMA, a fmall flat ifland, which is feparated from Cape Nota in Japan by a channel about five leagues wide. Its circumference does not exceed two leagues; it is well wooded, of an agreeable afpect, and well inhabited. Peroufe, who failed round it, remarked from the quarter-deck of his fhip fome confiderable edifices between the houfes of the inhabitants; and hard

Journals. Joyst.

hard by a fort or castle at the south-west point of the island, he [illegible] some gibbets. He does not, however, affirm that these gibbets were for the execution of criminals, for, as he observes, it would be [illegible] much if the Japanese, whose customs are so different from ours [illegible] in this point to resembles us so nearly. He re[illegible]s the island as surrounded with dreadful breake[rs] [illegible] the distance of a league and a half from which, he had constantly 60 fathoms, with rocky bottom. He places the island (differently, according to the editor of his voyage, from all other geographers) in latitude 37° 51′ north, and in Long. 135° 20 east from Paris.

JOURNALS, the title of periodical publications. See *Encyclopædia*. The principal British Journals are: *The History of the Works of the Learned*, begun at London in 1699. *Censura Temporum*, in 1708. About the same time there appeared two new ones; the one under the title of *Memoirs of Literature*, containing little more than an English translation of some articles in the foreign Journals, by M. de la Roche; the other, a collection of loose tracts, intitled, *Bibliotheca Curiosa*, or a Miscellany. These, however, with some others, are now no more, but are succeeded by the *Annual Register*, which began in 1758; the *New Annual Register*, begun in 1780; the *Monthly Review*, which began in the year 1749, and gives a character of all English literary publications, with the most considerable of the foreign ones: the *Critical Review*, which began in 1756, and is nearly on the same plan: as also the *London Review*, by Dr Kenrick, from 1775 to 1780; *Maty's Review*, from Feb. 1782 to Aug. 1786; the *English Review*, begun in Jan. 1783; and the *Analytical Review*, begun in May 1788, dropt in 1798, and revived in 1799, under the title of the *New Analytical Review*; but again dropt after two or three months trial: the *British Critic*, begun in 1792, and still carried on with much spirit and ability: the *Anti-Jacobin Review and Magazine*, commenced in 1798, for the meritorious purpose of counteracting the pernicious tendency of French principles in politics and religion: the *New London Review*, January 1799: *A Journal of Natural Philosophy, Chemistry, and the Arts*, which was begun in 1797 by Mr Nicholson, and has been conducted in such a manner, that it is one of the most valuable works of the kind to be found in any language: the *Philosophical Magazine*, begun in 1798 by Mr Tilloch, and carried on upon much the same plan, and with much the same spirit, as Nicholson's Journal.

Besides these, we have several monthly pamphlets, called *Magazines*, which, together with a chronological series of occurrences, contain letters from correspondents, communicating extraordinary discoveries in nature and art, with controversial pieces on all subjects. Of these, the principal are those called the *Gentleman's Magazine*, which began with the year 1731; the *London Magazine*, which began a few months after, and has lately been discontinued; the *Universal Magazine*, which is nearly of as old a date; the *Scotch Magazine*, which began in [1]739, and is still continued; the *European Magazine*; and the *Monthly Magazine*, a miscellany of much information, but not of [illegible]d principles.

JOYST or Jeyst, the second month of the Bengal year.

IRPATTOBAT, Membranes or [illegible], are the [illegible] same as *[illegible]* [illegible] ALGEBRA, *Encycl.*

Irreducible.

IRREDUCIBLE Case, in algebra, is used for that case of cubic equations where the root, according to Cardan's rule, appears under an impossible or imaginary form, and yet is real.

It is remarkable that this case always happens, *viz.* one root, by Cardan's rule, in an impossible form, whenever the equation has three real roots, and no impossible ones, but at no time else.

If we were possessed of a general rule for accurately extracting the cube root of a binomial radical quantity, it is evident we might resolve the irreducible case generally, which consists of two of such cubic binomial roots. But the labours of the algebraists, from Cardan down to the present time, have not been able to remove this difficulty. Dr Wallis thought that he had discovered such a rule; but, like most others, it is merely tentative, and can only succeed in certain particular circumstances.

IRON, is by much the most useful of all the metals, as has been sufficiently proved under the article Iron, *Encycl.* and under Chemistry in this *Supplement.* The word is again introduced here, because it affords us an opportunity of laying before our readers some valuable observations by Chaptal on the use of the *oxyds* of iron in dyeing cotton.

"The oxyd of iron has such an affinity for cotton thread, that if the latter be plunged in a saturated solution of iron in any acid whatever, it immediately assumes a chamoy yellow colour, more or less dark, according to the strength of the liquors. It is both a curious and easy experiment, that when cotton is made to pass through a solution of the sulphat of iron, rendered turbid by the oxyd which remains suspended in the liquor, it will be sufficient to dip the cotton in the bath to catch the last particle of the oxyd, and to restore to the liquor the transparency it has lost. The solution, then, which before had a yellowish appearance, becomes more or less green, according as it is more or less charged.

"The colour given to cotton by the oxyd of iron becomes darker, merely by exposure to the air; and this colour, soft and agreeable when taken from the bath, becomes harsh and ochry by the progressive oxydation of the metal. The colour of the oxyd of iron is very fast: it resists not only the air and water, but also alkaline leys, and soap gives it splendour without sensibly diminishing its intensity. It is on account of these properties that the oxyd of iron has been introduced into the art of dyeing, and been made a colouring principle of the utmost value.

"In order that the oxyd of iron may be conveniently applied to the cotton thread, it is necessary to begin by effecting its solution; and, in this case, acids are employed as the most useful solvents. Dyers almost everywhere make a mystery of the acid which they employ; but it is always the acetous, the sulphuric, the nitric, or the muriatic. Some of them ascribe great differences to the solution of iron by the one or the other acid; but, in general, they give the preference to the acetous. This predilection appears to be founded much less on the difference of the colours that may be communicated by the one or the other salt, than on the different degrees of corrosive power which each exercises on the stuff. That of the sulphat and muriat is so great,

that if the stuff be not washed when it comes from the bath, it will certainly be burnt; whereas solutions by the acetous, or any other vegetable acid, are not attended with the like inconvenience.

"Iron appears to be at the same degree of oxydation in the different acids, since it produces the same shade of colour when precipitated; and any acid solvent may be employed indiscriminately, provided the nature of the salt, and the degree of the saturation of the acid, be sufficiently known; for the subsequent operations may be then directed according to this knowledge, and the inconveniences which attend the use of some of these salts may be prevented. This, without doubt, is a great advantage which the man of science enjoys over the mere workman, who is incapable of varying his process according to the nature and state of the salts which he employs.

"1. If the sulphat of iron, or any other martial salt, be dissolved in water, and cotton be dipped in the liquid, the cotton will assume a chamoy colour, more or less dark according as the solution is more or less charged. The affinity of the cotton to the iron is so great, that it attracts the metal, and takes it in a great measure from the acid by which it was dissolved.

"2. If the iron of a pretty strong solution be precipitated by an alkaline liquor that shews five or six degrees (by the areometer of Baumé), the result will be a greenish blue magma. The cotton macerated in this precipitate assumes at first an unequal tint of dirty green; but mere exposure to the air makes it in a little time turn yellow, and the shade is very dark.

"It is by such, or almost similar processes, that dyers communicate what is called among workmen an *ochre* or *rust colour*. But these colours are attended with several inconveniences to the artist: 1. Strong shades burn or injure the cloth: 2. This colour is harsh, disagreeable to the eye, and cannot be easily united with the mild colours furnished by vegetables."

To avoid these inconveniences, our author made several attempts, which led him to the following practice: He treads the cotton cold in a solution of the sulphat of iron, marking three degrees; he wrings it carefully, and immediately plunges it in a ley of potash at two degrees, upon which he has previously poured to saturation a solution of the sulphat of alumine: the colour is then brightened, and becomes infinitely more delicate, soft, and agreeable. The sulphat no longer attacks the tissue of the stuff; and after the cotton has been left in the bath for four or five hours, it is taken out to be wrung, washen, and dried. In this manner we may obtain every shade that can be wished, by graduating the strength of the solutions. This simple process, the theory of which presents itself to the mind of every chemist, has the advantage of furnishing a colour very agreeable, exceedingly fixed, and, above all, extremely economical. He employs it with great advantage in dyeing nankeens, as it has the property of resisting leys. It becomes brown, however, by the action of astringents.

M. Chaptal made several attempts to combine this yellow with the blue of indigo, in order to obtain a durable green; but as they were all unsuccessful, he infers that there is not a sufficient affinity between the blue of indigo and the oxyds of iron. He found that these oxyds, on the other hand, combine very easily with the red of madder, and produce a bright violet or plum colour, the use of which is as extensive as beneficial in the cotton manufactory. But if we should confine ourselves to apply these two colours to cotton, without having employed a mordant capable of fixing the latter, the colour would not only remain dull and disagreeable by the impossibility of brightening it, but it would still be attended with the great inconvenience of not resisting leys. We must begin, then, by preparing the cotton as if to dispose it for receiving the Adrianople red; and when it has been brought to the operation of galling, it is to be passed through a solution of iron, more or less charged, according to the nature of the violet required: it is then to be carefully washed, twice maddered, and brightened in a bath of soap.

When a real velvety rich violet is required, it is not to be passed through the solution of iron till it has been previously galled; the iron is then precipitated in a bluish oxyd, which, combined with the red of madder, gives a most brilliant purple, more or less dark according to the strength of the galling and of the ferruginous solution. It is very difficult to obtain an equal colour by this process; and in manufactories, an equal violet is considered as a master-piece of art. It is generally believed, that it is only by well-directed manipulations that it is possible to resolve this problem, of so much importance in dyeing. But I am convinced (says our author), that the great cause of the inequality in this dye is, that the iron deposited on the cotton receives an oxydation merely by exposure to the air, which varies in different parts of it. The threads which are on the outside of the hank are strongly oxydated, while those in the inside, removed from the action of the air, experience no change. It thence follows, that the inside of the hank presents a weak shade, while the exterior part exhibits a violet almost black. The means to remedy this inconvenience is, to wash the cotton when it is taken from the solution of iron, and to expose it to the madder moist. The colour will become more equal and velvety. The solvents of iron are almost the same for this colour as for the yellow colour already mentioned.

The following observation may serve to guide the artist in brightening the violet on his cotton. The red of madder and the oxyd of iron deposited on the stuff determine the violet colour. This colour becomes red or blue, according as either of the principles predominates. The dyer knows by experience how difficult it is to obtain a combination which produces the tone of colour desired, especially when it is required to be very full, lively, and durable. This object, however, may be obtained, not only by varying the proportions of the two colouring principles, but also by varying the process of brightening. The only point is to be acquainted with the two following facts; that the soda destroys the iron, while the soap, by strong ebullition, seizes in preference the red of the madder. Hence it is, that the colour may be inclined to red or blue, according as you brighten with one or the other of these mordants. Thus, cotton taken from the madder dye, when washed and boiled in the brightening liquor with $\frac{1}{25}$ths of soap, will give a superb violet; whereas you will obtain only a plum colour in treating it with soda.

The oxyd of iron precipitated on any stuff unites also very advantageously with the fawn colour furnished

by astringents; and by varying the strength of mordants, an infinity of shades may be produced. In this case, it is less a combination or solution of principles than the simple mixture or juxta-position of the colouring bodies on the stuff. By means of a boiling heat, we may combine, in a more intimate manner, the oxyd of iron with the astringent principle; and then it is brought to the state of black oxyd, as has been observed by Berthollet. It is possible also to embrown these colours, and to give them a variety of tints, from the bright grey to the deep black, by merely passing the cottons impregnated with the astringent principle thro' a solution of iron. The oxyd is then precipitated itself by the principle which is fixed on the stuff.

An observation, which may become of the utmost value for the art of dyeing, is, that the most usual astringent vegetables all furnish a yellow colour, which has not much brilliancy, but which has sufficient fixity to be employed with advantage. This yellow colour is brightened in the series of vegetables, in proportion as the astringent principle is diminished, and the vivacity of the colour is augmented in the same proportion. It is difficult, then, to obtain yellow colours which are at the same time durable and brilliant. These two valuable qualities are to each other in an inverse ratio; but it is possible to unite the colouring principles in such a manner as to combine splendour with fixity. Green oak bark unites perfectly with yellow weed, and sumach with green citron. It is by this mixture that we may be able to combine with the oxyd of iron vegetable colours, the splendour of which is equal to their durability.

Our author concludes his observations with cautioning the dyer against substituting sumach and the bark of the alder tree or oak for gall when dyeing cotton red. "I can safely assert (says he), that it is impossible to employ these as substitutes, in whatever doses they may be used. The colour is always much paler, poorer, and less fixed. I know that the case is not the same in regard to dyeing wool and silk, in which it may be employed with success; and in giving an account of this difference, I think the cause of it may be found in the nature of the gall-nuts. 1. The acid which they exclusively contain, as Berthollet has proved, facilitates the decomposition of the soap with which the cottons have been impregnated, and the oil then remains fixed in their tissue, and in a greater quantity, as well as in a more intimate combination. 2. The gall-nuts, which owe their development to animal bodies, retain a character of animalisation, which they transmit to the vegetable stuff, and by these means augment its affinities with the colouring principle of the madder; for it is well known of what utility animal substances are to facilitate this combination. This animalisation becomes useless in operating upon woollen or silk."

JUAN DE FUCA, a celebrated strait on the north-west coast of America, was surveyed by Captain Vancouver in the Discovery sloop of war, with a view to ascertain whether it leads to any communication between the North Pacific and the North Atlantic Oceans. As they advanced within the opening of the strait, their progress was greatly retarded by the number of inlets into which the entrance branched in every direction; and most of these were examined by the boats, which were frequently absent from the ships on this service for several days together. In the midst of their labours, they were surprised by the sight of two Spanish vessels of war, employed, like themselves, in surveying this inlet, the examination of which had been begun by them in the preceding year. Measures of mutual assistance were concerted between the captains of the two nations for the prosecution of the survey, in which each agreed to communicate to the other their discoveries. Not one of the many arms of the inlet, nor of the channels which they explored in this broken part of the coast, was found to extend more than 100 miles to the eastward of the entrance into the strait. After having surveyed the southern coast, on which side a termination was discovered to every opening, by following the continued line of the shore, they were led to the northward, and afterward towards the north-west, till they came into the open sea through a different channel from the strait of Juan de Fuca, by which they had commenced this inland navigation.

Thus it appeared, that the land forming the north side of that strait is part of an island, or of an archipelago, extending nearly 100 leagues in length from S. E. to N. W.; and on the side of this land most distant from the continent is situated Nootka Sound. The most peculiar circumstance of this navigation is the extreme depth of water, when contrasted with the narrowness of the channels. The vessels were sometimes drifted about by the currents during the whole of a night, close to the rocks, without knowing how to help themselves, on account of the darkness, and the depth being much too great to afford them anchorage.

In the course of this survey, the voyagers had frequent communications with the natives, whom they met sometimes in canoes and sometimes at their villages. In their transactions with Europeans, they are described as "well versed in the principles of trade, which they carried on in a very fair and honourable manner." In other respects they were less honest. At one village 200 sea otter skins were purchased of them by the crews of the vessels in the course of a day; and they had many more to sell in the same place, as also skins of bears, deer, and other animals. One party of Indians whom they met had the skin of a young lioness; and these spoke a language different from that used in Nootka Sound. Venison was sometimes brought for sale; and a piece of copper, not more than a foot square, purchased one whole deer and part of another. Among other articles of traffic, two children, six or seven years of age, were offered for sale. The commodities most prized by the natives were fire-arms, copper, and great coats. Beads and trinkets they would only receive as presents, and not as articles of exchange. Many of them were possessed of fire-arms. In one part it is related, that after a chief had received some presents, "he, with most of his companions, returned to the shore; and, on landing, fired several muskets, to shew, in all probability, with what dexterity they could use these weapons, to which they seemed as familiarized as if they had been accustomed to fire-arms from their earliest infancy."

The dresses of these people, besides skins, are a kind of woollen garments; the materials composing which are explained in the following extract:

"The dogs belonging to this tribe of Indians were numerous, and much resembled those of Pomerania, though,

though, in general, somewhat larger. They were all shorn as close to the skin as sheep are in England; and so compact were their fleeces, that large portions could be lifted up by a corner without causing any separation. They were composed of a mixture of a coarse kind of wool, with very fine long hair, capable of being spun into yarn. This gave Captain Vancouver reason to believe, that their woollen clothing might in part be composed of this material mixed with a finer kind of wool from some other animal, as their garments were all too fine to be manufactured from the coarse coating of the dog alone."

Of other animals alive, deer only were seen in any abundance by our people.

The number of inhabitants computed to be in the largest of the villages or towns that were discovered, did not exceed 600. Captain Vancouver conjectured the small pox to be a disease common and very fatal among them. Many were much marked; and most of these had lost their right eye. Their method of disposing of their dead is very singular.

"Baskets were found suspended on high trees, each containing the skeleton of a young child; in some of which were also small square boxes filled with a kind of white paste, resembling (says our author) such as I had seen the natives eat, supposed to be made of the saranne root; some of these boxes were quite full, others were nearly empty, eaten probably by the mice, squirrels, or birds. On the next low point south of our encampment, where the gunners were airing the powder, they met with several holes in which human bodies were interred, slightly covered over, and in different states of decay, some appearing to have been very recently deposited. About half a mile to the northward of our tents, where the land is nearly level with high water mark, a few paces within the skirting of the wood, a canoe was found suspended between two trees, in which were three human skeletons.

"On each point of the harbour, which, in honour of a particular friend, I called *Penn's Cove*, was a deserted village; in one of which were found several sepulchres, formed exactly like a centry box. Some of them were open, and contained the skeletons of many young children tied up in baskets: the smaller bones of adults were likewise noticed, but not one of the limb bones could here be found; which gave rise to an opinion, that these, by the living inhabitants of the neighbourhood, were appropriated to useful purposes; such as pointing their arrows, spears, or other weapons."

However honourably these people have been represented in their conduct as traders, it appeared on several occasions that it was unsafe to depend on their goodwill alone: and some instances occurred, of their making every preparation for an attack, from which they desisted only on being doubtful of the event; yet immediately on relinquishing their purpose, they would come with the greatest confidence to trade, appearing perfectly regardless of what had before been in agitation. The boats, as already noticed, were frequently at a great distance from the ships; and on such occasions, when large parties of Indians have first seen them, they generally held long conferences among themselves before they approached the boats; probably for the purpose of determining the mode of conduct which they judged it most prudent to observe. Captain Vancouver places the entrance of the strait of Juan de Fuca in 48° 20′ N. Lat. and 124° W. Long.

Jugglers.

JUGGLERS are a kind of people whose profession has not been often deemed either respectable or useful. Professor Beckmann, however, has undertaken their defence; and in a long and learned chapter in the third volume of his *History of Inventions*, pleads the cause of the practisers of legerdemain, rope dancers; persons who place their bodies in positions apparently dangerous; and of those who exhibit feats of uncommon strength. All these men he classes under the general denomination of *Jugglers*; and taking it for granted (surely upon no good grounds) that every useful employment is full, he contends, that there would not be room on the earth for all its present inhabitants did not some of them practise the arts of *Juggling*.

"These arts (says he) are indeed not unprofitable, for they afford a comfortable subsistence to those who practise them; but their gain is acquired by too little labour to be hoarded up; and, in general, these roving people spend on the spot the fruits of their ingenuity; which is an additional reason why their stay in a place should be encouraged. But farther, it often happens, that what ignorant persons first employ, merely as a show, for amusement or deception, is afterwards ennobled by being applied to a more important purpose. The machine with which a Savoyard, by means of shadows, amused children and the populace, was by Liberkühn converted into a solar microscope; and, to give one example more, the art of making ice in summer, or in a heated oven, enables guests, much to the credit of their hostess, to cool the most expensive dishes. The Indian discovers precious stones, and the European, by polishing, gives them a lustre.

"But, if the arts of juggling served no other end than to amuse the most ignorant of our citizens, it is proper that they should be encouraged for the sake of those who cannot enjoy the more expensive deceptions of an opera. They answer other purposes, however, than that of merely amusing: they convey instruction in the most acceptable manner, and serve as an agreeable antidote to superstition, and to that popular belief in miracles, exorcism, conjuration, sorcery, and witchcraft, from which our ancestors suffered so severely."

Surely this reasoning, as well as the cause in which it is brought forward, is unworthy of the learning of Beckmann. It is indeed true, that jugglers spend their money freely, and that their arts afford them the means of subsistence; but it is very seldom, as our author must know, that they subsist either comfortably or innocently. Is it innocent to entice the ignorant and labouring poor, by useless deceptions, to part with their hard earned pittance to idle vagabonds? or is the life of those vagabonds comfortable, when it is passed amid scenes of the most grovelling dissipation? Jugglers spend indeed their money, for the most part, on the spot where it is gained; but they spend it in drunkenness, and other seducing vices, which corrupt their own morals and the morals of all with whom they associate; and therefore their stay in a place should certainly *not* be encouraged. Could it be proved that the solar microscope would never have been invented, had not a Savoyard juggler contrived a similar machine to amuse children and the rabble, some stress might be laid on the service which such wretches have

Jugglers. have rendered to science: but where is the man that will suppose the philosophy of Bacon and Newton to rest upon the arts of jug[illegible]? or who considers the refinements of science as of equal value with the morals of the people? There is, at the moment in which this article is drawing up, a fellow exhibiting, before the windows of the writer's chamber, the most indecent scenes by means of puppets, and keeping the mob in a constant roar. Is he innocently employed? or will any good man say that there is not room for him in the armies which on the Continent are fighting in the cause of God and humanity?

Our author endeavours to strengthen his reasoning by proving, which he does very completely, the antiquity of juggling. "The deception (says he) of breathing out flames, which at present excites, in a particular manner, the astonishment of the ignorant, is very ancient. When the slaves in Sicily, about a century and a half before our æra, made a formidable insurrection, and avenged themselves in a cruel manner for the severities which they had suffered, there was amongst them a Syrian named Eunus, a man of great craft and courage, who, having passed through many scenes of life, had become acquainted with a variety of arts. He pretended to have immediate communication with the gods; was the oracle and leader of his fellow slaves; and, as is usual on such occasions, confirmed his divine mission by miracles. When, heated by enthusiasm, he was desirous of inspiring his followers with courage, he breathed flames or sparks among them from his mouth while he was addressing them. We are told by historians, that for this purpose he pierced a nut-shell at both ends, and, having filled it with some burning substance, put it into his mouth and breathed through it.

"This deception, at present, is performed much better. The juggler rolls together some flax or hemp, so as to form a ball about the size of a walnut; sets it on fire; and suffers it to burn till it is nearly consumed; he then rolls round it, while burning, some more flax; and by these means the fire may be retained in it for a long time. When he wishes to exhibit, he slips the ball unperceived into his mouth and breathes through it; which again revives the fire, so that a number of weak sparks proceed from it; and the performer sustains no hurt, provided he inspire the air not through the mouth but the nostrils.

"For deceptions with fire the ancients employed also naphtha, a liquid mineral oil, which kindles when it only approaches a flame. (See NAPHTHA, *Encycl.*) Galen informs us, that a person excited great astonishment by extinguishing a candle and again lighting it, without any other process than holding it immediately against a wall or a stone. The whole secret of this consisted in having previously rubbed over the wall or stone with sulphur. But as the author, a few lines before, speaks of a mixture of sulphur and naphtha, we have reason to think that he alludes to the same here. Plutarch relates how Alexander the Great was astonished and delighted with the secret effects of naphtha, which were exhibited to him at Ecbatana. The same author, as well as Pliny, Galen, and others, has already remarked, that the substance with which Medea destroyed Creusa, the daughter of Creon, was nothing else than this fine oil. She sent to the unfortunate princess a dress besmeared with it, which burst into flames as soon as she approached the fire of the altar. The blood of Nessus, in which the dress of Hercules, which took fire likewise, had been dipped, was undoubtedly naphtha also; and this oil must have been always employed when offerings caught fire in an imperceptible manner.

Jugglers Jungle.

"In modern times, persons who could walk over burning coals or red-hot iron, or who could hold red-hot iron in their hands, have often excited wonder. But laying aside the deception sometimes practised on the spectators, the whole of this secret consists in rendering the skin of the soles of the feet and hands so callous and insensible, that the nerves under them are secured from all hurt, in the same manner as by shoes and gloves. Such callosity will be produced if the skin is continually compressed, singed, pricked, or injured in any other manner. Thus do the fingers of the industrious sempstress become horny by being frequently pricked; and the case is the same with the hands of fire-workers, and the feet of those who walk bare footed over scorching sand.

"In the month of September 1765, when I visited (says our author) the copper-works at Awestad, [illegible] the workmen, for a little drink money, took [illegible] the melted copper in his hand, and after shewing [illegible] us, threw it against a wall. He then squeezed the fingers of his horny hand close to each other, [illegible] it a [illegible] minutes under his arm-pit, to make it sweat, as he said; and, taking it again out, drew it over a ladle filled with melted copper, some of which he skimmed off, and moved his hand backwards and forwards very quickly, by way of ostentation. While I was viewing this performance, I remarked a smell like that of singed horn or leather, though his hand was not burnt. It is highly probable, that people who hold in their hands red hot iron, or who walk upon it, as I saw done at [illegible]terdam, but at a distance, make their skin callous before, in the like manner. This may be accomplished by frequently moistening it with spirit of vitriol; according to some the juice of certain plants will produce the same effect; and we are assured by others, that the skin must be very frequently rubbed, for a long time, with oil, by which means, indeed, leather also will become horny *."

Our author then proves, in a very learned manner, that all these tricks were of high antiquity; that the Hirpi, who lived near Rome, jumped through burning coals; that women were accustomed to walk over burning coals at Castabala in Cappadocia, near the temple dedicated to Diana; that the exhibition of balls and cups (see LEGERDEMAIN, *Encycl.*) is often mentioned in the works of the ancients; that in the third century, one Firmus or Firmius, who endeavoured to make himself emperor in Egypt, suffered a smith to forge iron on an anvil placed on his breast; that rope-dancers with balancing poles are mentioned by Petronius and others; and that the various feats of horsemanship exhibited in our circuses passed, in the thirteenth century, from Egypt to the Byzantine court, and thence over all Europe.

JUNGLE, in Bengal, waste land, or land covered with wood and brambles.

K.

Kaarta.

KAARTA, a kingdom in Africa, through which Mr Park passed in his route from the Gambia to the Niger. He describes the country as consisting either of sandy plains or rocky hills; but, from his account, the level part seems to be the most extensive. The natives are negroes, of whom many, though converted to the Mahomedan faith, or rather to the ceremonial part of the Mahomedan religion, retain all their ancient superstitions, and even drink strong liquors. They are called Johers or Jowers, and in Kaarta form a very numerous and powerful tribe. One of these men undertook to conduct our author to Kemmoo, the capital of the kingdom, and alarmed him not a little by his superstitious ceremonies.

"We had no sooner (says Mr Park) got into a dark and lonely part of the first wood, than he made a sign for us to stop, and taking hold of a hollow piece of bamboo, that hung as an amulet round his neck, whistled very loud, three times. I confess I was somewhat startled, thinking it was a signal for some of his companions to come and attack us; but he assured me that it was done merely with a view to ascertain what success we were likely to meet with on our present journey. He then dismounted, laid his spear across the road, and having said a number of short prayers, concluded with three loud whistles; after which he listened for some time, as if in expectation of an answer, and receiving none, told us we might proceed without fear, for there was no danger."

White men were strangers in the kingdom of Kaarta; and the appearance of our author had on some of the natives the effect which ignorant people, in this country, attribute to ghosts. "I had wandered (says he) a little from my people, and being uncertain whether they were before or behind me, I hastened to a rising ground to look about me. As I was proceeding towards this eminence, two negro horsemen, armed with muskets, came galloping from among the bushes: on seeing them I made a full stop; the horsemen did the same, and all three of us seemed equally surprised and confounded at this interview. As I approached them their fears increased, and one of them, after casting upon me a look of horror, rode off at full speed; the other, in a panic of fear, put his hand over his eyes, and continued muttering prayers until his horse, seemingly without the rider's knowledge, conveyed him slowly after his companion. About a mile to the westward, they fell in with my attendants, to whom they related a frightful story: it seems their fears had dressed me in the flowing robes of a tremendous spirit; and one of them affirmed, that when I made my appearance, a cold blast of wind came pouring down upon him from the sky like so much cold water."

At Kemmoo our traveller was graciously received by the king; who honestly told him, however, that he could not protect him, being then engaged in war with the king of BAMBARRA (see SEGO in this *Supplement*); but he gave him a guard to JARRA, the frontier town of the neighbouring kingdom of Ludamar. The origin and issue of this war between Kaarta and Bambarra, of which Mr Park gives a full account, shews the folly of attempting to liberate the negroes from slavery till civilization and Christianity be introduced into Africa. Major Rennel places Kemmoo, the capital of Kaarta, in 14° 15′ N. Lat. and 7° 20′ W. Lon.

Kabobiquas.

KABOBIQUAS, a nation in south Africa, who had never seen a white man till 1785, that they were visited by M. Vaillant. Intimation had been given of his approach by some of the tribes through whose country he had previously passed; and every thing that had been said of his colour, his fusees, and his equipage, bore the character of the most enthusiastic exaggeration. The curiosity of the people was wound up to the highest pitch; and as soon as they saw his company at a distance, the whole horde quitted the kraal, and ran with eagerness to meet him. Not being able to believe their eyes in regard to what they saw, they endeavoured to obtain more satisfaction by touching him. They felt his hair, hands, and almost every part of his body. His beard, above all, astonished them to an inconceivable degree. More than thirty persons came in succession, and half unbuttoned his clothes. They all imagined him to be a hairy animal; and supposed, without doubt, that his body was covered with hair as long as that on his chin; but finding this not to be the case, they were astonished, and confessed, with the openness of savages, that they had never seen the like in any man of their country. The little children, terrified at his appearance, hid themselves behind their mothers. When he attempted to lay hold of any of them, in order to caress them, they sent forth loud cries, as a child would do in Europe who should see a negro for the first time.

The grown up people, however, were soon reconciled to his appearance, and even the children were bribed by small bits of sugar candy. The chief of the horde showed him every mark of attachment. He was a man advanced in life, and of a majestic figure. He wore a long mantle, which hung from his shoulders to the ground, and which, formed of four jackal skins joined together, was bordered at the sides with that of a hyæna. His left hand wanted two joints of the little finger, which, he said, were amputated in his infancy to cure him of a severe illness.

This custom of savages, who, to relieve a man from pain, add new sufferings to his evils, affords a vast field for reflection. Mr Paterson, another African traveller, tells us, that he observed instances of the same practice among a horde at the mouth of Orange-river; which is not improbable. However absurd a custom may be, savage tribes, when they are neighbours, may borrow it from each other; but that it should be common among the islanders of the South Sea, who, since their country was first inhabited, had never seen strangers before Cook and Bougainville, is truly astonishing. Our author was very desirous of interrogating minutely the people of the horde on this subject. He wished also to propose some questions to them respecting other customs which appeared singular; but difficulties increased the more he advanced into the country. The Kabobiquas spoke a particular language, and this dialect, though

 accompanied

Kabobiquas accompanied with the clapping noise of the Hottentots, was understood only by the Koraquas, who, on account of their vicinity, kept up some intercourse with them. The case was the same with the language of the Koraquas, in regard to their neighbours the Nimiquas; and nothing reached our author's ear till it had passed through four different mouths. The consequence was, that when he asked any thing, the answer had frequently no relation to the question; and for this inconveniency no remedy could be found.

The same desire for trinkets to ornament their dress prevailed among the Kabobiquas as among the other hordes which Vaillant had visited; and in one day he purchased twenty oxen for things of that kind of no value. The chief, however, had set his affections on a razor; and just when our author and he were treating about it, a shot was fired near them, which was instantly followed by the most frightful cries. "Rushing instantly from my tent (says M. Vaillant) to enquire what was the cause of this noise, I saw a Kabobiqua flying as fast as he could from one of my hunters, while, at the distance of a hundred paces farther, three men were making the most lamentable clamour, and near them was a young girl lying on the ground. I made a signal to my hunter to approach me; but the report of the shot, and the howling of the three men, had already spread alarm throughout the horde. Some cried out treachery; others ran to their arms; and I now imagined that I was about to be massacred, with my whole company, and that I should be obliged to arm them in my defence. My situation was the more critical, as neither I, nor any person in the kraal, knew what was the cause of this confusion; and if I had known, how could I have explained it?

"Under this embarrassment, I took the chief by the hand, and advanced with him towards the horde. Fear was painted in his countenance; tears began to drop from his eyes; and he spoke to me with great vivacity. He imagined, no doubt, that he was betrayed. He complained to me, and accused my people of perfidy; yet he readily followed me.

"As I was without arms, and presented myself with the chief, I was received with confidence, and my appearance seemed, in some measure, to calm their perturbation. My people, who had seen me direct my course towards the kraal, hastened thither after me, to protect me; and their number overawed the multitude. At length the whole mystery was cleared up, and we learned what had occasioned the tumult.

"A Kabobiqua having met one of my hunters, who was returning with his fusee, wished to examine it, and begged him to shew it to him. In handling it, however, he accidentally touched the trigger; it instantly went off; and the savage, frightened by the unexpected explosion, threw down the fusee, and ran away as fast as he could.

"At that time, three men of the horde and a young girl happened unluckily to be standing, at the distance of a hundred paces, in the direction of the piece. The latter received a single grain of shot in the cheek; and the others a few grains in the legs and thighs. The author of the misfortune confirmed this explanation; tranquillity was soon restored; the savages deposited their arms; and I was surrounded only by friends as before.

"Nothing remained but to enquire into the state of the wounded, and to give them every assistance in my power. Without loss of time, therefore, I repaired, still accompanied by the chief, to the place where they were. By the way we met the young girl, who was returning from the kraal, bathed in tears. The cause of her uneasiness was a grain of lead, which had, however, penetrated so little, that I forced it out by only pressing the part with my fingers. With regard to the three men, they lay rolling on the ground, howling in a most frightful manner, and exhibiting every symptom of despair.

"I was astonished at their consternation, and could not conceive how men inured to sufferings should be so much affected by a few small punctures, the pain of which could have scarcely drawn tears from an infant. They at length told me the cause of their wailings. These savages, accustomed to poison their arrows, imagined that I had in like manner poisoned the lead with which they were wounded. They had, therefore, given themselves up as lost, and expected in a few moments to expire."

It was with great difficulty that our author could convince them that they had nothing to fear. He shewed them in the flesh of his own leg a dozen of shots of lead; but they were not satisfied till one of the most intelligent of his Hottentots, taking from his shot bag a few grains of lead, and shewing them to the three men, immediately swallowed them. This conclusive argument produced the desired effect. The cries of the wounded men instantly ceased; serenity again appeared in their faces; and their wounds were no more mentioned.

The Kabobiquas have neither the flat nose nor plump cheeks of the Hottentots. Their skin also has not that bastard colour, which, being neither black nor white, renders them odious to both races; nor do they besmear their bodies with those disgusting fat substances, on account of which one cannot approach them without being bedaubed with their filth, or acquiring an offensive smell. In stature they are as tall as the Caffres, and their colour is equally black. Their hair, which is exceedingly short, and much curled, is ornamented with small copper buttons, arranged with great art and symmetry. Instead of that apron made of a jackal's skin, employed by the Hottentot to cover what modesty bids him conceal, the Kabobiquas use a round piece of leather, the edge of which is ornamented with a small indented circle of copper, and which is divided into different compartments by rows of glass beads of various colours, all proceeding from the centre, and diverging towards the circumference, like the rays in our images of the sun.

This kind of veil is made fast to the groin by means of a girdle; but as it is only four inches in diameter, as it is deranged by the smallest movement, and as they give themselves little uneasiness respecting such accidents, it is very ill suited to the purpose for which it is applied. During the great heats, this small and almost useless apron is the only covering on their bodies. Its being so readily displaced, enabled our author to ascertain that they do not practice circumcision; but it seemed to show also, that, in regard to modesty, their ideas are very different from ours.

Though they go thus almost entirely naked, their manners, instead of being licentious, are remarkably chaste.

Kainsi, Kamtschatka.

like theirs, is rounded at the end; and as it is always accustomed, both in leaping and walking, to tread with the point of the hoof, without resting at all on the heel, it leaves a print distinguishable from that of any other antelope in Africa. Its flesh is exquisitely flavoured, and much sought after, particularly by the hunters.

The chace of the kainsi is very amusing. It is true, it is scarcely possible to hunt it down with dogs, as it soon escapes them by means of its inconceivable agility, and gets out of their reach on the point of some detached rock, where it will remain whole hours safe from all pursuit, and suspended, as it were, above the abyss. But in this situation it is excellently placed for the arrow or the ball of the huntsman; who is commonly certain of shooting it at pleasure, though he is not always able to come at it when killed. We shall give our author's account of a chace of the kainsi in his own words.

"I was hunting (says he) one of these animals, when, from the nature of the place, it found itself so pressed by my dogs, as to be on the point of being run down and taken. There were apparently no means of escape; since before it was a vast perpendicular rock, by which its course was necessarily stopped. In this wall, however, which appeared to me perfectly smooth, was a little ridge, projecting at most not above *two inches*, which the kainsi quickly perceived, and, leaping upon it, to my great astonishment kept itself *firm* (A). I imagined, that at any rate it must soon tumble down; and my dogs, too, so fully expected it, that they ran to the bottom of the rock, to be ready to catch it when it fell. To hasten its fall, I endeavoured to harass it, and make it lose its equilibrium; and for this purpose I pelted it with stones. All at once, as if guessing my design, it collected its whole strength, bounded over my head, and, falling a few paces from me, darted away with the utmost speed. Notwithstanding the rapidity of its flight, it would have been easy for me to have shot it; but its leap had so surprised and amused me, that I gave it its life." This was generous, if the story be true.

KAMTSCHATKA is inhabited by a people, who are represented in the *Encyclopædia* as possessing almost every quality that can disgrace human nature. We think it incumbent upon us to acknowledge, in this place, that a much more favourable picture of them is drawn by La Perouse who visited Kamtschatka in September 1787. The Russian governor made the commodore and his officers remark the promising appearance of several small fields of potatoes, of which the seed had been brought from Irkoutsk a few years before; and purposed to adopt mild, though infallible means, of making farmers of the Russians, Cossacks, and Kamtschadales. The small-pox in 1769 swept away three-fourths of the individuals of the latter nation, which is now reduced to less than four thousand persons, scattered over the whole of the peninsula; and which will speedily disappear altogether, by means of the continual mixture of the Russians and Kamtschadales, who frequently intermarry. A mongrel race, more laborious than the Russians, who are only fit for soldiers, and much stronger, and of a form less disgraceful to the hand of nature, than the Kamtschadales, will spring from these marriages, and succeed the ancient inhabitants. The natives have already abandoned the *yourts*, in which they used to burrow like badgers during the whole of the winter, and where they breathed an air so foul as to occasion a number of disorders. The most opulent among them now build *isbas*, or wooden houses, in the manner of the Russians They are precisely of the same form as the cottages of our peasants; are divided into three little rooms; and are warmed by a brick stove, that keeps up a degree of heat (B) insupportable to persons unaccustomed to it. The rest pass the winter, as well as the summer, in *balagans*, which are a kind of wooden pigeon-houses, covered with thatch, and placed upon the top of posts twelve or thirteen feet high, to which the women as well as the men climb by means of ladders that afford a footing very insecure. But these latter buildings will soon disappear; for the Kamtschadales are of an imitative genius, and adopt almost all the customs of their conquerors. Already the women wear their hair, and are almost entirely dressed, in the manner of the Russians, whose language prevails in all the *ostrogs*; a fortunate circumstance, since each Kamtschadalian village spoke a different jargon, the inhabitants of one hamlet not understanding that of the next. It may be said in praise of the Russians, that though they have established a despotic government in this rude climate, it is tempered by a mildness and equity that render its inconveniences unfelt. They have no reproaches of atrocity to make themselves, like the Spaniards in Mexico and Peru. The taxes they levy on the Kamtschadales are so light, that they can only be considered as a mark of gratitude towards the sovereign, the produce of half a day's hunting acquitting the imposts of a year. It is surprising to see in cottages, to all appearance more miserable than those of the most wretched hamlets in our mountainous provinces, a quantity of species in circulation, which appears the more considerable, because it exists among so small a number of inhabitants. They consume so few commodities of Russia and China, that the balance of trade is entirely in their favour, and that it is absolutely cessary to pay them the difference in rubles. Furs at Kamtschatka are at a much higher price than at Canton; which proves, that as yet the market of Kiatcha has not felt the advantageous effect of the new channel opened in China.

Our author compares Kamtschatka, with respect to climate and soil, to the coast of Labrador in the vicinity of the Straits of Belle-Isle; but the men, like the animals, are there very different. The Kamtschadales appeared to him the same people as those of the bay of Castries, upon the coast of Tartary. Their mildness and their probity are the same, and their persons are very little different. They ought then no more to be compared to the Esquimaux Indians, than the sables of Kamtschatka to the martins of Canada.

The Greek religion has been established among the Kamtschadales without persecution or violence, and with extraordinary facility. The vicar of Paratounka is the son of a Kamtschadale and of a Russian woman. He delivers his prayers and catechism with a tone of feeling very

(A) This we think incredible.
(B) Not less than thirty degrees of Reaumur's thermometer.

very much to the taſte of the aborigines, who reward his cares with offerings and alms, but pay no tythes. The canons of the Greek church permitting prieſts to marry, we may conclude that the morals of the country clergymen are ſo much the better. "I believe them, however (ſays Perouſe), to be very ignorant; and do not ſuppoſe, that for a long time to come they will ſtand in need of greater knowledge. The daughter, the wife, and the ſiſter of the vicar, were the beſt dancers of all the women, and appeared to enjoy the beſt ſtate of health. The worthy prieſt knew that we were good Catholics, which procured us an ample aſperſion of holy water; and he alſo made us kiſs the croſs that was carried by his clerk: theſe ceremonies were performed in the midſt of the village. His parſonage-houſe was a tent, and his altar in the open air; but his uſual abode is Paratounka, and he only came to St Peter and St Paul's to pay us a viſit."

The people of Kamtſchatka have inured themſelves to the extremes of heat and cold. It is well known, that their cuſtom in Europe, as well as in Aſia, is to go into vapour baths, come out covered with perſpiration, and immediately roll themſelves in the ſnow. The *oſtrog* of St Peter had two of theſe public baths, into which our author went before the fires were lighted. They conſiſt of a very low room, in the middle of which is an oven conſtructed of ſtones, without cement, and heated like thoſe intended to bake bread. Its arched roof is ſurrounded by ſeats one above another, like an amphitheatre, for thoſe who wiſh to bathe, ſo that the heat is greater or leſs according as the perſon is placed upon a higher or lower bench. Water thrown upon the top of the roof, when heated red-hot by the fire underneath, is converted inſtantly into vapour, and excites the moſt profuſe perſpiration. The Kamtſchadales have borrowed this cuſtom, as well as many others, from their conquerors; and ere long the primitive character that diſtinguiſhed them ſo ſtrongly from the Ruſſians will be entirely effaced.

Our author deſcribes the bay of Avatſcha as the fineſt, the moſt convenient, and the ſafeſt, that is to be met with in any part of the world. The entrance is narrow, and ſhips would be forced to paſs under the guns of the forts that might be eaſily erected. The bottom is mud, and excellent holding ground. Two vaſt harbours, one on the eaſtern ſide, the other on the weſtern, are capable of containing all the ſhips of the French and Engliſh navy. The rivers of Avatſcha and Paratounka fall into this bay, but they are choaked up with ſand-banks, and can only be entered at the time of high water. The village of St Peter and St Paul is ſituated upon a tongue of land, which, like a jetty made by human art, forms behind the village a little port, ſhut in like an amphitheatre, in which three or four veſſels might lie up for the winter. The entrance of this ſort of baſon is more than twenty-five toiſes wide; and nature can afford nothing more ſafe or commodious. On its ſhore the governor propoſed to lay down the plan of a city, which ſome time or other will be the capital of Kamtſchatka, and perhaps the centre of an extenſive trade with China, Japan, the Phillippines, and America. A vaſt pond of freſh water is ſituated northward of the ſite of this projected city; and at only three hundred toiſes diſtance run a number of ſtreamlets, the eaſy union of which would give the ground all the advantages neceſſary to a great eſtabliſhment. Of theſe advantages Mr Kaſloff underſtood the value; "but firſt (ſaid he a thouſand times over) we muſt have bread and hands, and our ſtock of both of them is very ſmall." He had, however, given orders, which announced a ſpeedy union of the other *oſtrogs* to that of St Peter and St Paul, where it was his intention immediately to build a church. By obſervation, St Peter and St Paul was found to be in 53° 1′ N. Lat. and 156° 30′ E. Long. from Paris.

KANEM, is the name given by Edriſi to the kingdom of Bornou in Africa, of which the reader will find ſome account in the *Encyclopædia Britannica*. In ſome particulars, however, that account is incorrect. The kingdom of Bornou or Kanem muſt extend farther eaſt and farther north than it is there ſaid to do; for according to the lateſt and beſt accounts, its capital ſtands in Lat. 24° 32′ Long. 22° 57′. The empire is ſaid to be very extenſive; and if it be true, as we learn from the proceedings of the African Aſſociation, that its ſovereign is more powerful than the Emperor of Morocco, the people cannot be ſuch abſolute brutes, as we have repreſented them in the article referred to; for the ſovereign of brutes would have no power. The truth, however is, that very little is yet known in Europe of Bornou or its inhabitants.

KANT (*Immanuel*), Royal Profeſſor of Morals and Metaphyſics in the Univerſity of Königſberg, is conſidered by his admirers as the greateſt philoſopher that Germany ever produced. Were we to form an eſtimate of his merits from the different views that have been given in Engliſh of his celebrated ſyſtem, we certainly ſhould not conſider him as entitled to that character; for thoſe views are obſcured by new and uncouth terms, and are altogether wrapt up in a ſtyle which approaches nearer to jargon than to the luminous compoſition of a man who thinks with clearneſs and preciſion. We readily admit, that it is very difficult to tranſlate a novel ſyſtem of metaphyſics from one language into another; for the tranſlator, to perform his taſk properly, muſt be not only a complete maſter of both languages, but alſo a profound metaphyſician; and not one of the tranſlators or abridgers of the works of Kant into our language appears to us poſſeſſed of both theſe qualities. Deſpairing, from our ſcanty knowledge of the German language, of performing ourſelves what ſo many others have failed to perform, we have applied for aſſiſtance to an illuſtrious Frenchman, who has reſided many years in Germany, who is maſter of both languages, who is a profound metaphyſician, and whoſe name, were we at liberty to publiſh it, would reflect luſtre upon our Work. From him we have reaſon to expect a clear and comprehenſive view of the *Critical* PHILOSOPHY, as Kant terms his ſyſtem; but ſhould we be diſappointed of our expectation, we ſhall, under that title, lay before our readers a *ſpecimen* of the ſyſtem from the different views of it which have been publiſhed in our own tongue.

KANTUFFA, a ſpecies of thorn peculiar to Abyſſinia, is thus deſcribed by Mr Bruce: The branches ſtand two and two upon the ſtalk; the leaves are diſpoſed two and two likewiſe, without any ſingle one at the point, whereas the branches bearing the leaves part from the ſtalk: at the immediate joining of them are two thick thorns placed perpendicular and parallel alternately;

Kantuffa, Kaffon.

ly; but there are alfo fingle ones diftributed in all the interftices throughout the branch.

The male plant has a one-leaved perianthium, divided into five fegments, and this falls off with the flower. The flower is compofed of five petals, in the middle of which rife ten ftamina or filaments, the outer row fhorter than thofe of the middle, with [illegible] ftigmata, having yellow farina upon them. The flowers grow in a branch, generally between three and four inches long, in a conical difpofition, that is, broader at the bafe than the point. The infide of the leaves are a vivid green, in the outfide much lighter. It grows in form of a bufh, with a multitude of fmall branches rifing immediately from the ground, and is generally feven or eight feet high. Our author faw it when in flower only, never when bearing fruit. It has a very ftrong fmell, refembling that of the fmall fcented flower called mignionet, fown in vafes and boxes in windows, or rooms, where flowers are kept.

Our author reprefents the kantuffa as fo very troublefome, that it renders travelling through fome places of Abyffinia almoft impoffible. The foldier fcreens himfelf from it by a goat's, a leopard's, or a lion's fkin thrown over his fhoulder, of which it has no hold. As his head is bare, he always cuts his hair fhort before he goes to battle, left his enemy fhould take advantage of it; but the women, wearing their hair long, and the great men, whether in the army or travelling in peace, being always clothed, it never fails to incommode them, whatever fpecies of raiment they wear. If their cloak is fine muflin, the leaft motion againft it puts it all in rags; but if it is a thick, foft cloth, as thofe are with which men of rank generally travel, it buries its thorns, great and fmall, fo deep in it, that the wearer muft either difmount and appear naked, which to principal people is a great difgrace, or elfe much time will be fpent before he can difengage himfelf from its thorns. In the time when one is thus employed, it rarely fails to lay hold of you by the hair, and that again brings on another operation, full as laborious, but much more painful, than the other. A proclamation is therefore iffued, every year immediately before the king commences any march, in thefe words; "Cut down the kantuffa in the four quarters of the world; for I do not know where I am going." The wild animals, both birds and beafts, efpecially the Guinea fowl, know how well it is qualified to protect them. In this fhelter, the hunter in vain could endeavour to moleft them, were it not for a hard haired dog, or terrier of the fmalleft fize, who being defended from the thorns by the roughnefs of his coat, goes into the cover, and brings them and the partridges alive one by one to his mafter.

KASSON, a populous kingdom in North Africa, of which the capital *Kooniakary* is placed by Major Rennel in 14° 33′ N. Lat. and 8° 43′ W. Lon. The king who reigned when Mr Park was in the country was extremely kind to our traveller, though his fon plundered him unmercifully, like other rapacious chiefs of that favage country. From the top of a high hill, at fome diftance from the capital, "I had (fays Mr Park) a moft enchanting profpect of the country. The number of towns and villages, and the extenfive cultivation around them, furpaffed every thing I had yet feen in Africa. A grofs calculation may be formed of the number of inhabitants in this delightful plain, by confidering, that the king of Kaffon can raife four thoufand fighting men by the found of his war drum."

At Teefee, a large unwalled town, where our author refided for fome days, he had an opportunity of obferving the cuftoms of the inhabitants, who confifted partly of Pagans and partly of Bufhreens, *i. e.* of negroes converted to Mahomedanifm. Though thefe people poffefs both cattle and corn in abundance, rats, moles, fquirrels, fnakes, locufts, &c. are eaten without fcruple by the higheft and loweft. Another cuftom, ftill more extraordinary, is, that no woman is allowed *to eat an egg.* This prohibition, whether arifing from ancient fuperftition, or from the craftinefs of fome old Bufhreen who loved eggs himfelf, is rigidly adhered to; and nothing will more affront a woman of Teefee than to offer her an egg. The cuftom is the more fingular, as the men eat eggs without fcruple in the prefence of their wives, and Mr Park never obferved the fame prohibition in any other of the Mandingo countries.

Our author was prefent at a palaver held by the governor of Teefee on a very extraordinary occafion; of which we fhall give his account at full length, becaufe it fhows how free men are reduced to flavery in North Africa. "The cafe was this. A young man, a Kafir, of confiderable affluence, who had recently married a young and handfome wife, applied to a very devout Bufhreen, or Muffulman prieft, of his acquaintance, to procure him faphies for his protection during the approaching war. The Bufhreen complied with the requeft; and in order, as he pretended, to render the faphies more efficacious, enjoined the young man to avoid any nuptial intercourfe with his bride for the fpace of fix weeks. Severe as the injunction was, the Kafir ftrictly obeyed; and without telling his wife the real caufe, abfented himfelf from her company. In the mean time it began to be whifpered at Teefee, that the Bufhreen, who always performed his evening devotions at the door of the Kafir's hut, was more intimate with the young wife than he ought to be. At firft, the good hufband was unwilling to fufpect the honour of his fanctified friend, and one whole month elapfed before any jealoufy rofe in his mind: but hearing the charge repeated, he at laft interrogated his wife on the fubject, who frankly confeffed that the Bufhreen had feduced her. Hereupon the Kafir put her into confinement, and called a palaver upon the Bufhreen's conduct. The fact was clearly proved againft him; and he was fentenced to be fold into flavery, or to find two flaves for his redemption, according to the pleafure of the complainant. The injured hufband, however, was unwilling to proceed againft his friend to fuch extremity, and defired rather to have him publicly flogged before the governor's gate. This was agreed to, and the fentence was immediately executed. The culprit was tied by the hands to a ftrong ftake; and a long black rod being brought forth, the executioner, after flourifhing it round his head for fome time, applied it with fuch force and dexterity to the Bufhreen's back, as to make him roar until the woods refounded with his fcreams. The furrounding multitude, by their hooting and laughing, manifefted how much they enjoyed the punifhment of this old gallant; and it is worthy of remark, that the number of ftripes was precifely the fame as are enjoined by the Mofaic law, *forty, fave one.*"

The method of converting the negro nations to the religion

Kasson. religion of the Arabian Impostor is a very singular one; and Mr Park saw the whole people of Teesee converted in an instant. During his residence in that town an embassy of ten people belonging to Almami Abdulkader, king of Foota Torra, a country to the west of Bondou, arrived at Teesee; and desiring Tiggity Sego the governor to call an assembly of the inhabitants, announced publicly their king's determination, to this effect: "That unless all the people of Kasson would embrace the Mahomedan religion, and evince their conversion by saying eleven public prayers, he (the king of Foota Torra) could not possibly stand neuter in the present contest, but would certainly join his arms to those of Kajaaga." A message of this nature, from so powerful a prince, could not fail to create great alarm; and the inhabitants of Teesee, after a long consultation, agreed to conform to his good pleasure, humiliating as it was to them. Accordingly, one and all publicly offered up eleven prayers, which were considered a sufficient testimony of their having renounced Paganism, and embraced the doctrines of the Prophet.

Our author relates a story, which we cannot refuse ourselves the pleasure of inserting, because it exhibits a very pleasing picture of the affection and gratitude of the Pagan negroes. In his train was a blacksmith, who had lived some years on the Gambia, and who now returned to his own country *Kasson*. "Soon after we came in sight of Jumbo, his native town (says Mr Park), his brother, who had by some means been apprised of his coming, came out to meet him, accompanied by a singing man; he brought a horse for the blacksmith, that he might enter his native town in a dignified manner; and he desired each of us to put a good charge of powder into our guns. The singing man now led the way, followed by the two brothers; and we were presently joined by a number of people from the town, all of whom demonstrated great joy at seeing their old acquaintance the blacksmith, by the most extravagant jumping and singing. On entering the town, the singing man began an extempore song in praise of the blacksmith, extolling his courage in having overcome so many difficulties; and concluding with a strict injunction to his friends to dress him plenty of victuals.

"When we arrived at the blacksmith's place of residence, we dismounted and fired our muskets. The meeting between him and his relations was very tender; for these rude children of nature, free from restraint, display their emotions in the strongest and most expressive manner. Amidst these transports, the blacksmith's aged mother was led forth, leaning upon a staff. Every one made way for her; and she stretched out her hand to bid her son welcome. Being totally blind, she stroked his hands, arms, and face, with great care, and seemed highly delighted that her latter days were blessed by his return, and that her ears once more heard the music of his voice. From this interview I was fully convinced, that whatever difference there is between the Negro and European in the conformation of the nose and the colour of the skin, there is none in the genuine sympathies and characteristic feelings of our common nature.

"During the tumult of these congratulations, I had seated myself apart, by the side of one of the huts, being unwilling to interrupt the flow of filial and parental tenderness; and the attention of the company was so entirely taken up with the blacksmith, that I believe none of his friends had observed me. When all the people present had seated themselves, the blacksmith was desired by his father to give them some account of his adventures; and silence being commanded, he began; and after repeatedly thanking God for the success that had attended him, related every material occurrence that had happened to him from his leaving Kasson to his arrival at the Gambia; his employment and success in those parts; and the dangers he had escaped in returning to his native country. In the latter part of his narration, he had frequently occasion to mention me; and after many strong expressions concerning my kindness to him, he pointed to the place where I sat, and exclaimed, *affille ibi siring*, "see him sitting there." In a moment all eyes were turned upon me; I appeared like a being dropped from the clouds; every one was surprised that they had not observed me before; and a few women and children expressed great uneasiness at being so near a man of such an uncommon appearance. By degrees, however, their apprehensions subsided; and when the blacksmith assured them that I was perfectly inoffensive, and would hurt nobody, some of them ventured so far as to examine the texture of my clothes; but many of them were still very suspicious; and when by accident I happened to move myself, or look at the young children, their mothers would scamper off with them with the greatest precipitation. In a few hours, however, they all became reconciled to me." With these worthy people our author spent the greater part of two days in feasting and merriment; the blacksmith accompanied him to the capital; and declared, that he would not leave him while he resided there. Kasson, Keate.

KEATE (George, Esq; F. R. S.), descended of an ancient and honourable family, was born about the year 1729 or 1730, and received his education at Kingston school, under the Rev. Mr Woodeson. From thence he went to Geneva, where he resided some years, and during his stay there, became acquainted with Voltaire, with whom he continued to correspond many years after he returned to England. After finishing the tour of Europe, he settled as a student in the Inner Temple, was called to the bar, and sometimes attended Westminster Hall; though he did not meet with encouragement enough to induce his perseverance in his profession, nor indeed does it seem probable that he had sufficient application for it. His first literary performance was "Ancient and Modern Rome," a poem, written at Rome in the year 1755, printed in the year 1760, and received with considerable applause. The next year he published "A Short Account of the Ancient History, Present Government, and Laws, of the Republic of Geneva, 8vo." This work was compiled during the author's residence at Geneva; is a very useful one; and is dedicated to Monsieur de Voltaire: to whom he says, "When I reflect, that it was in this Republic, whose government I have attempted to describe, that I was first introduced to your acquaintance; when memory renews the hours of social mirth and refined entertainment which your hospitality and conversation afforded me—I cannot but rejoice in this occasion of expressing my gratitude; proud that, as your friendship distinguished the author of these pages in a foreign country, your name may at home adorn his labour."

It

Keate. It was at one time the intention of Voltaire to translate this account into French, though he afterwards relinquished the design.

The next year, 1762, he produced an "Epistle from Lady Jane Gray to Lord Guildford Dudley:" and in 1763, "The Alps," a poem; the subject of which comprehends all that chain of mountains known under the general name of the Alps, extending from Italy to Germany, and from France to Tyrol, by whatever denomination they are particularly distinguished. Of all the poetical works of Mr Keate, this is intitled to the highest praise for truth of description, elegance of versification, and vigour of fancy.

Continuing to employ the press, in 1764 he published "Netley Abbey," which he afterwards, in 1769, enlarged and reprinted; and, in 1765, produced "The Temple Student, an Epistle to a Friend;" humourously rallying his own want of application to the study of the law, his preference of the belles lettres, and his consequent want of success in his profession. The death of Mrs Cibber in 1766, of whose merits as an actress he entertained the highest opinion, gave occasion for a poem to her memory, which celebrates her excellent performances on the stage, and laments the loss the theatre would sustain by her death.

In February 1769, he married Miss Hudson; and about the same time published "Ferney; an Epistle to M. de Voltaire" In this poem, after praising with energy the various beauties of his friend's poetical works, he introduces the following panegyric on Shakespeare:

Yes! jealous wits may still for empire strive,
Still keep the flames of critic rage alive:
Our Shakespeare yet shall all his rights maintain,
And crown the triumphs of Eliza's reign.
Above controul, above each classic rule,
His tut'ress Nature, and the world his school,
On soaring pinions borne, to him was given
Th' ærial range of Fancy's brightest heav'n;
To bid wrapt thought o'er noblest heights aspire,
And wake each passion with a muse of fire.
Revere his genius. To the dead be just,
And spare the laurels that o'ershade the dust.
Low sleeps the bard, *in cold obstruction laid*,
Nor asks the chaplet from a rival's head.
O'er the drear vault, Ambition's utmost bound,
Unheard shall Fame her airy trumpet sound!
Unheard alike; nor grief nor transport raise
The blast of censure, or the note of praise!
As Raphael's own creation grac'd his hearse,
And sham'd the pomp of ostentatious verse,
Shall Shakespeare's honours by himself be paid,
And Nature perish ere his pictures fade.

This eulogium on Shakespeare, in an an epistle to Voltaire, who had laboured so long and so strenuously to detract from the merit of our immortal bard, shews that Mr Keate had not given up his judgment to the sage of Ferney. How the old and envious sophister would relish his friend's conduct, may be easily conceived. His feelings were certainly very different from those of the mayor and burgesses of Stratford, when, in consequence of this panegyric on their townsman, they complimented Mr Keate with a standish, mounted with silver, made out of the famous Mulberry tree planted by Shakespeare.

In 1773, he published "The Monument in Arcadia," a dramatic poem, built on the picture of Poussin, mentioned by Abbé du Bos in his "Critical Reflections on Poetry and Painting." Keate.

In 1779, Mr Keate produced one of his most successful works, intitled "Sketches from Nature; taken and coloured in a Journey to Margate," 2 vols, 12mo. This performance, allowing it to be, as it really is, an imitation of Sterne's "Sentimental Journey;" yet contains so many pleasing delineations of life, so many strokes of humour, and so much elegance of composition, that few will hesitate to give it the preference to any other of Sterne's imitators.

In 1781, he collected his poetical works in two vols, 12mo, and added several new pieces not before printed. The principal of these was "The Helvetiad," a fragment, written at Geneva in the year 1756. In the preface to this performance he gives the following account of it: "During a long stay I many years since made at Geneva, I visited most of the principal places in Switzerland. The many sublime scenes with which nature hath enriched this romantic country; the tranquillity and content with which every individual enjoys his property; and, above all, that independence of mind which is ever the result of liberty—animated me with such veneration for the first authors of that freedom, whose figures are recorded to posterity either by sculpture or painting in the public parts of the towns thro' those little states, that my enthusiasm betrayed me into a design of writing a poem on this singular revolution; the argument of which I had divided into *ten cantos*, beginning the work with the oppressions of the House of Austria, and closing it with the battle of Mongarten; by which those injured people finally renounced its usurpation, and formed among themselves those various confederacies that ended in the great union and alliance of the present *thirteen cantons*. When I had settled the whole plan of this work, I occasionally, as I found a disposition in myself, took up any part of the poem which at the moment most invited my thoughts: and enjoying at this time such an intercourse with M. de Voltaire as afforded me a constant access to him, I acquainted him with my intention, shewing him the argument I had drawn out for the conduct of the whole design. He kept it a few days; and, in returning it, told me, that he thought the great object of the piece, the episodes connected with the history, together with the scenery of the country, presented subject matter whereon to form a fine poem; "but the time (added he) which such an undertaking will require, I would rather counsel you to employ on subjects that might more engage the public attention; for should you devote yourself to the completion of your present design, the Swiss would be much obliged to you, without being able to read you, and the rest of the world care little about the matter." Feeling the force and justness of the remark; Mr Keate laid aside his plan, and probably never resumed it. In the same year, 1781, he published "An Epistle to Angelica Kauffman."

A few years after, he became engaged in a long and vexatious law-suit, in consequence of the neglect (to say the least of it) of an architect who professed himself to be his friend; the particulars of which it is of no importance to detail. At the conclusion of the business, he shewed that his good humour had not forsaken him:

And

Keate. And in 1787 he gave to the public the principal circumſtances of his caſe in a performance, intitled, "The Diſtreſſed Poet, a ſerio-comic Poem, in three Cantos," 4to, with ſome pleaſantry, and without any acrimony.

His laſt work did infinite honour to his head and his heart, as well as to the liberality of the bookſeller for whom on the title-page it was ſaid to be publiſhed. In the year 1782, the Antelope packet was ſhipwrecked on the Pelew iſlands, where the commander, Captain Wilſon, and his crew lived ſome time before they could get off. On his return to England, the Captain was, for ſome reaſon or other, refuſed the command of another ſhip; and, as we have been informed, he was reduced to a ſtate much the reverſe of affluence. Theſe circumſtances being communicated to Mr Keate, who was ſtruck with admiration of the manners of the inhabitants of the Pelew iſlands (See Pelew Islands, *Encycl.*), he offered to draw up, for the benefit of Captain Wilſon, a narrative of the occurrences which took place during that officer's reſidence among ſo ſingular a people. This he executed in "An Account of the Pelew Iſlands, ſituated in the Weſtern Part of the Pacific Ocean: compoſed from the Journals and Communications of Captain Henry Wilſon and ſome of his Officers, who in Auguſt 1783 were there ſhipwrecked, in the Antelope, a Packet belonging to the Honourable the Eaſt India Company," 4to; a work written with great elegance, compiled with much care, and which, if embelliſhed (as it has been inſinuated) with facts better calculated to have found a place in a novel than a genuine narrative, muſt be aſcribed to the miſinformation of thoſe who were actors in the ſcene, and muſt firſt have deceived before they obtained credit. We mention this report as it has come to us, without any attempt either to eſtabliſh or refute it. We ſhall only add, that if the charge is well founded, Mr Keate (who undertook the taſk on the moſt diſintereſted principle, and derived no advantage whatever from the work) was too ſturdy a moraliſt to have had any hand in the impoſition.—The manuſcript was offered to Mr Dodſley for 300 guineas; but he heſitated to give for it ſo large a price, when another bookſeller undertook to publiſh the work for the benefit of Mr Wilſon; and, we have reaſon to believe, paid to that gentleman, within the compaſs of a year, triple the ſum for which the manuſcript had been offered to Dodſley. Such conduct reflects honour on the London trade.

Beſides the pieces already mentioned, Mr Keate was the author of many Prologues and Epilogues, ſpoken at Mr Newcomb's ſchool at Hackney. He adapted his friend Voltaire's "Semiramis" to the ſtage; but this was ſuperſeded in 1777 at Drury Lane, by a worthleſs tranſlation of as worthleſs an author, one Captain Ayſcough; but neither this nor the author are deſerving of any further notice.

We ſhall conclude by obſerving, that Mr Keate's life paſſed without any viciſſitudes of fortune; he inherited an ample eſtate, which he did not attempt to increaſe otherwiſe than by thoſe attentions which prudence dictated in the management of it. He was hoſpitable and beneficent, and poſſeſſed the good-will of mankind in a very eminent degree. For the laſt year or two, his health viſibly declined; but on the day he died, it appeared to be ſomewhat mended. His death was ſudden, on the 27th of June 1797. He left one daughter, married in 1796 to John Henderſon, Eſq; of the Adelphi. At the time of his death, Mr Keate was a Bencher of the Temple, and a very old member of the Royal and Antiquary Societies, of both of which he had been frequently elected one of the council.

KENNICOTT (Dr Benjamin) was a man of ſuch eminence in the learned world, that every thing relating to him muſt be generally intereſting. In the biographical ſketch of him publiſhed in the *Encyclopædia*, we have acknowledged ourſelves unacquainted with the rank and character of his parents; but this information has been ſince ſupplied by a very candid and well-informed writer in the Monthly Magazine; and as it is accompanied with circumſtances peculiarly honourable to the Doctor, and ought therefore to be preſerved, we ſhall inſert it in this place. Kennicott.

"The parents of Dr Kennicott (ſays this writer) were honeſt characters: His father was the pariſh clerk of Totneſs, and once maſter of a charity ſchool in that town. At an early age young Kennicott ſucceeded to the ſame employ in the ſchool, being recommended to it by his remarkable ſobriety and premature knowledge. It was in that ſituation he wrote the verſes to the honourable Mrs Courtney, which recommended him to her notice, and that of many neighbouring gentlemen. They, with a laudable generoſity, opened a ſubſcription to ſend him to Oxford.

"He ſoon there diſtinguiſhed himſelf, as is well known. As a teſtimony of the truth of the above ſtatement, the following is a copy of an inſcription written by Dr Kennicott, and engraved on the tomb of his father and mother. The writer of this article has tranſcribed it from the original in the church-yard of Totneſs. The tomb is more elegant than perſons in their ſituation are accuſtomed to have erected, and was thought, perhaps, by the envious to be ſomewhat oſtentatious. A perſonal knowledge of the Doctor induces the writer of this article to think, that it was rather the tribute of a good and grateful mind, and of the pious reverence and love which he entertained for the authors of his being.

As Virtue ſhould be of good report,
ſacred
be this humble Monument
to the Memory of
Benjamin Kennicott, Pariſh Clerk of Totneſs,
and Elizabeth his Wife:
The latter
an Example of every Chriſtian Duty;
The former,
animated with the warmeſt Zeal,
regulated by the beſt good ſenſe,
and both conſtantly exerted
for the Salvation of himſelf and others.
Reader!
Soon ſhalt thou die alſo;
and as a Candidate for Immortality
ſtrike thy breaſt and ſay,
Let me live the life of the Righteous,
that my laſt end may be like his.
Trifling are the dates of Time
where the ſubject is Eternity.
Erected
by their Son, B. Kennicott, D. D.
Canon of Chriſt-Church, Oxford.

"It is ſaid, that when Dr Kennicott had taken orders, he came to officiate in his clerical capacity in his native

native town. When his father as clerk proceeded to place the surplice on his shoulders, a struggle ensued between the modesty of the son and the honest pride of the parent, who insisted on paying that respect to his son which he had been accustomed to shew to other clergymen: to this filial obedience was obliged to submit. A circumstance is added, that his mother had often declared she should never be able to support the joy of hearing her son preach; and that on her attendance at the church for the first time, she was so overcome as to be taken out in a state of temporary insensibility."

KERMES (see *Coccus Ilicis*, Encycl.) has been proved by Professor Beckmann to have been used as a dye from very remote antiquity. "All the ancient Greek and Latin writers, he says, agree, that kermes, called by the latter *coccum*, perhaps also *coccus*, and often *granum*, were found upon a low shrubby tree, with prickly leaves, which produced acorns, and belonged to the genus of the oak; and there is no reason to doubt that they mean *coccum ilicis*, and that low ever green oak, with the prickly leaves of the holly (*aquifolium*), which is called at present in botany *quercus ilex*. This assertion appears more intitled to credit, as the ancients assign for the native country of this tree places where it it is still indigenous, and produces kermes.

"I am inclined (continues our author) to believe, that the art of employing kermes to dye a beautiful red colour was discovered in the East at a very early period; that it was soon so much improved as to excel even the Tyrian purple; and that it contributed to cause the proper purple to be at length abandoned. From the costly red dyes extolled so much by the Hebrew writers, and which, according to the opinion of learned commentators, were made from kermes, I shall not venture to adduce any proofs, as I am not acquainted with the Oriental languages to examine their accounts with accuracy; but I have found a passage in Vopiscus, which seems to render my conjecture very probable. That author informs us, that the king of Persia sent to the Emperor Aurelian, besides other articles of great value, some woollen cloth, which was of a much costlier and brighter purple colour than any that had been ever seen in the Roman empire, and, in comparison of which, all the other purple cloth worn by the Emperor and the ladies of the court appeared dull and faded. In my opinion, this cloth, which was of a beautiful purple red colour, was not dyed with the liquor of the murex, but with kermes. This idea was indeed not likely to occur to the Romans, who were acquainted only with the purple of the murex, and who had less experience in the arts in general than in that of robbing and plundering, or who, at any rate, in that respect were inferior to the Orientals. The Roman emperors caused this supposed purple to be sought for in India by the most experienced dyers; who, not being able to find it, returned with a vague report that the admired Persian purple was produced by the plant sandix. I am well aware, that some commentators have supposed that the sandix was our madder. Hesychius, however, says, very confidently, that the *sandix* is not a plant, but a kind of shrubby tree, which yields a dye like the *coccus*. The Roman dyers, perhaps prejudiced in favour of the murex, made that only the object of their search; and their labour proving fruitless, they might have heard something of kermes, or the kermes-oak, which they did not fully understand. Our dyers, even at present, believe many false accounts respecting the dye-stuffs which they use daily."

The use of kermes in dyeing seems to have been continued through every century. In the middle ages, as they are called, we meet with kermes under the name of *vermiculus* or *vermiculum*; and on that account cloth dyed with them was called *vermiculata*. Hence the French word *vermeil*, and its derivative *vermilion*, as is well known, had their extraction; the latter of which originally signified the red dye of kermes, but it is now used for any red paint, and also for fine pounded cinnabar.

KHAS, in Bengal, lands taken into the hands of government, opposed to the management of Zemindars or farmers. See Zemindar in this *Supplement*.

KHALSA, in Bengal, sometimes with the addition of *Shereefah*, the department of land and revenues; the exchequer.

KHERAJE, in Bengal, signifies strictly the tribute paid by a conquered country: it is also used for revenue in general.

KHIDMUT, office, attendance, employment, service.

KHIDMUTGAR, a waiting man.

KHISMUT, portion or division.

KHOMAR, or Comar, a Zemindar's demesne land.

KING-POST, or King-*Piece*, is a piece of timber set upright in the middle, between two principal rafters, and having struts or braces going from it to the middle of each rafter. See Roof, *Encycl.*; and Carpentry, *Suppl.*

KIPPIS (Andrew, D. D. F. R. and A. S.), was born at Nottingham, March 28 (O. S.) 1725. His father, a respectable tradesman of that town, was descended from the Rev. Benjamin King of Oakham, Rutlandshire, an ejected minister; and his mother, Ann Ryther, was the grand-daughter of the Rev. John Ryther, who was ejected from the church of Ferby, in the county of York. In the year 1730, he lost his father, and went to reside with his grandfather, Andrew Kippis of Seaford in Lincolnshire. He received his classical education at the grammar school in that town; but what contributed most to his future eminence, was the friendship of the Rev. Mr Merrival, who was equalled by few of his contemporaries in various branches of learning, particularly in his acquaintance with the classics, his knowledge of ancient and modern history, and his refined taste in the belles lettres. Dr Kippis frequently said, that it was impossible for him to express his obligations to this friend of his youth. In 1741 he removed to Northampton, and commenced his academical studies under Dr Doddridge. After a residence of five years at the academy, he was invited by several congregations to become their minister. Though he was pressed to settle at Dorchester, and had been chosen their minister, he gave the preference to an invitation from Boston in Lincolnshire, where he went to reside in September 1746. Here he continued four years; and in November 1750, accepted the pastoral charge of a congregation at Dorking in Surry. The congregation meeting in Princes street Westminster, having been without a minister about two years, he was chosen in June 1753, to succeed the Rev. Dr Obadiah Hughes. On the 21st of September

Kippis. ber following, he married, at Boston, Miss Elizabeth Bott, one of the daughters of Mr Isaac Bott, a merchant of that place; and in the month of October fixed his residence in Westminster. In June 1767, he received the degree of D. D. from the university of Edinburgh, on the unsolicited recommendation of the late learned Professor Robertson. He was elected a member of the Society of Antiquaries on the 19th of March 1778; and on the 17th of June 1779, he was chosen a Fellow of the Royal Society. In both Societies he had the honour of being in the council two years.

Dr Kippis was eminently distinguished for the virtues and accomplishments which form the chief ornaments of private life. With a suavity of manners and urbanity of behaviour peculiarly attractive, he united that knowledge of men and books which rendered his conversation uncommonly entertaining and instructive to the circle of his acquaintance and friends. As a minister, he was not less eminent for his profound acquaintance with every branch of theology than for the happy manner in which he applied it to the improvement of those who attended his ministry. His sermons were remarkable for perspicuity, elegance, and energy; and his elocution was unaffected and very impressive, particularly at the close of his discourses. But the superior powers and vigour of mind which he derived from nature, and which he had cultivated with unremitting diligence and peculiar success, were not to be confined to the narrow limits of private life and the duties of the pastoral charge, however important; they were designed for more extensive and important services to his country and to mankind. The interests of literature, science, and religion, have received from the exertion of his talents as a writer the most essential advantages. His first efforts in literature were made in the Gentleman's Magazine, a periodical publication called the Library, and the Monthly Review; to each of which he contributed many important articles, especially in the historical and philological departments of the last. He was the author of three important tracts, viz. "A Vindication of the Protestant Dissenting Ministers, &c." "Observations on the late Contests in the Royal Society;" and "Considerations on the Treaty with America, &c." His improved edition of Dr Doddridge's Lectures is a work of great value; and "The History of Knowledge, Learning, and Taste, in Great Britain," prefixed to the New Annual Register, merits, and has received, the approbation of the public. He published at different times several single sermons; among which, that on the death of his friend the Rev. Mr Laugher, is intitled to very high praise. The greater part of these he republished, with other practical discourses, in the year 1794: but the work which, next to the studies immediately connected with his office as a Christian minister, engaged his principal attention, and by which he has long been distinguished, is, the improved edition of the "*Biographia Britannica*." In this great national publication, the comprehensiveness and powers of his mind, the correctness of his judgment, the vast extent of his information, his indefatigable researches and unremitting assiduity, his peculiar talent of appreciating the merits, and analyzing the labours of the most eminent writers, and his unshaken integrity, unbiassed fidelity, and impartial decision on the characters of the philosopher, statesman, poet, scholar, and divine, are strongly displayed, and universally acknowledged. His style, formed on the models of Sir William Temple and the classical Addison, is remarkable for its perspicuity, elegance, and purity; and gives a peculiar lustre to the rich stores of knowledge treasured in the volumes now published. This work has given him a high rank among the literati of his country, and will carry down his name with distinguished reputation to posterity. He died on the 8th October 1795.

Kol KOL-QUALL, the Abyssinian name of a tree, which some botanists have supposed to be the EUPHORBIA *Officinarum* of Linnæus. Mr Bruce, who gives the only description of the Kol-quall that we have seen, is of a different opinion: for which he assigns two reasons; the first is, that the flower, which he says is rosaceous, is composed of several petals, and is not companiform; and the second, that it produces no sort of gum, either spontaneously or upon incision. We must acknowledge, that we entertain some doubts whether our author was at due pains to ascertain this fact; and these doubts are suggested by his own history of the tree. His description is not very perspicuous, and therefore, lest we should misrepresent his meaning, we shall give it in his own words:

"The first thing that presented itself was the first shoot of this extraordinary tree. It was a single stalk, about six inches measured across, in eight divisions, regularly and beautifully scolloped and rounded at the top, joining in the centre at three feet and a half high. Upon the outside of these scollops were a sort of eyes or small knots, out of every one of which came five horns, four on the sides and one in the centre, scarce half an inch long, fragil, and of no resistance, but exceedingly sharp and pointed. Its next process is to put out a branch from the first or second scollop near the top, others succeed from all directions; and this stalk, which is soft and succulent, of the consistence of the aloe, turns by degrees hard and ligneous, and after a few years, by multiplying its branches, assumes the form of a tree, the lower part of which is wood, the upper part, which is succulent, has no leaves; these are supplied by the fluted, scolloped, serrated, thorny sides of its branches. Upon the upper extremity of these branches grow its flowers, which are of a golden colour, rosaceous, and formed of five round or almost oval petals; this is succeeded by a triangular fruit, first of a light green with a slight cast of red, then turning to a deep crimson, with streaks of white both at top and bottom. In the inside it is divided into three cells, with a seed in each of them; the cells are of a greenish white, the seed round, and with no degree of humidity or moisture about it; yet the green leaves contain a quantity of bluish watery milk almost incredible.

"Upon cutting two of the finest branches of a tree in its full vigour, a quantity of this issued out, which I cannot compute to be less than four English gallons; and this was so exceedingly caustic, that though I washed the sabre that cut it immediately, the stain has not yet left it.

"When the tree grows old, the branches wither, and, in place of milk, the inside appears to be full of powder, which is so pungent, that the small dust which I drew upon striking a withered branch, seemed to

threaten

threaten to make me freeze to death, and the touching of the milk with my fingers excoriated them as if scalded with boiling water; yet I everywhere observed the wood pecker piercing the rotten branches with its beak, and eating the insects, without any impression upon its olfactory nerves."

If what is milk in a young tree be a dry powder in one that is old, is it not probable that the milk might by evaporation be reduced to the consistence of gum, and that the kol quall may be at most but a variety of the *euphorbia officinarum?* From our author's observation, the kol-quall appeared to thrive best on poor, sandy, stony earth, at no great distance from the sea. The Abyssinians employ the milky juice in tanning to take off the hair from the skins, and they make no other use whatever of the tree.

KOONA, a species of ECHITES (for which see *Encycl.*), very common in the woods of North Africa. It is a shrub, of which the leaves, when boiled with a small quantity of water, yield a thick black juice, into which the negroes dip a cotton thread. This thread they fasten round the iron of their arrows, in such a manner that it is almost impossible to extract the arrow when it has sunk beyond the barbs, without leaving the iron and the poisoned thread in the wound. The poison of the koona is said to be very deadly.—*Park's Travels.*

KORAQUAS, a tribe of Hottentots inhabiting a district of South Africa, which M. Vaillant places on the confines of the Nimiqua country (See NIMIQUAS, *Suppl.*). When our author visited them, the whole tribe was assembled for the election of a chief; and not agreeing among themselves, some blood had been shed, and much more would have been shed, had they not unanimously made choice of him. When he first joined them, the whole horde paid attention to nothing but their quarrel. To see their warmth, one might have supposed that their election was a matter of importance to the whole world, and that the fate of mankind was about to depend on their chief. All spoke at the same time; each endeavoured to drown his neighbour's voice by his own; their eyes sparkled with fury; and amidst this confusion, while they threatened each other in turns, the noise they made became truly dreadful.

Unarmed, and without any precaution, though surrounded by this enraged multitude, our author walked calmly along in the midst of them; and when he reached the kraal, he ordered his tent to be immediately formed, as if he had been surrounded by friends and relations. This appearance, raised suddenly, and as if by magic, before the eyes of the horde, with his fusees, horses, and tent, objects which were all new to them, filled them with admiration. Men, women, and children, motionless, and with their mouths wide open, all stood looking at them with profound silence. Anger, hatred, and every violent passion, seemed by their countenances to be extinguished; and to have given place to more tranquil emotions, to ignorant surprise, and stupid astonishment. Infancy is naturally curious; it is struck with every thing it sees; and the savage, in this respect, is only a grown-up child. As these savages seemed to wish that he would permit them to examine more closely whatever excited their admiration, he readily condescended to gratify their desire. They approached, surveyed, and handled every thing. But the principal object of general curiosity was his person. They seemed as if they would never be satisfied with looking at his dress. They pulled off his hat, that they might the better examine his hair and his beard, which were long. They even half unbuttoned his clothes; and surprised to see his skin white, each felt it, as if desirous to ascertain that what they saw was real.

This comedy continued till the evening; and at length, when the moment of separation arrived, M. Vaillant caused to be hinted to the whole company, that if, two hours after sun rise next morning, they should not be agreed respecting the choice of a chief, he would immediately leave them. He added, however, that if, on the other hand, they came and presented to him a chief, elected by general consent, he would then load them all with presents, and bestow on him a distinction which would raise him above all his equals, and render the horde one of the most celebrated in the whole country. "But what was my surprise (says he) when I learned the same evening, that on my head the burden of the crown was deposed!" He acquiesced, however; assuring them, that if they would promise to be obedient, he would give them the only chief worthy of ruling them, and of making them happy.

By his interpreters he had learned, that the choice of the majority leaned towards one Haripa, a man about 40 years of age; tall, well made, exceedingly strong, and consequently formed by nature for ruling the feeble multitude. He therefore named Haripa chief; and the people appearing to approve of his choice, he commanded silence, and causing the new monarch to approach, placed on his head, with great solemnity, a Dutch grenadier cap, of which the copperplate on the front was ornamented with the arms of Holland. This symbol, *viz.* a lion rampant, having in one of his fore-paws seven arrows, and in the other a naked sabre, could not fail to please the savages, as it exhibited a representation of the weapons peculiar to them, and of the most formidable animal of their country. They testified their admiration in the most expressive manner; and imagined that, superior to kings, the white man during the night had by magic made this crown, merely to adorn their chief, and to afford them pleasure. Vaillant then affixed to the skin, which formed Haripa's dress, several rows of glass beads; gave him a girdle made of a string of very large ones; ornamented his arms with tin bracelets, and suspended from his neck a small padlock, shaped like a butterfly, the key of which had been lost. Such padlocks, made in the form of animals of every kind, are very common at the Cape. They come from China; and are brought to Africa by the captains of the Company's ships which trade in the Indian seas.

During the ceremony of installation, the whole horde, dumb and motionless through admiration, seemed lost in ecstacy. Haripa himself, though highly gratified, did not dare to make the least movement, and observed a gravity altogether risible. When the inauguration was finished, and he was completely dressed, our author presented him with a mirror, that he might enjoy the satisfaction of surveying his own figure. He then shewed him to the people, who expressed their joy by shouts and applauses without end.

"Ye honest hearts (says M. Vaillant), who peruse this account, behold what it cost me to restore peace among

Koraquas. among a whole tribe, and to prevent them from destroying each other!" From this moment concord was re-established; universal joy prevailed through the horde; and they instantly began their dancings, which continued for three days and three nights without intermission. They killed for this festival several fat sheep, and even two oxen; an extraordinary and truly astonishing magnificence among a people who, when they barter one of their daughters for a cow, think they have made an excellent bargain.

Our author, wishing to purchase some oxen for his waggons, bought them at the price of a nail the ox; and those who had the good fortune to make such an exchange were highly satisfied with their bargain. Nails and small bits of iron were indeed of real value to them, to point the arrows and assageys, with which they shot the antelopes that abound in their country, and constitute much of their food. Like other savages, the Koraquas were ready to pilfer, and appropriate to their own use whatever they found pleasing, or suited to their purposes. They attempted to carry away some of our author's effects, even before his face; and to prevent their rapacity, he was obliged either to watch over, or to deposit them in some place of safety.

The Koraquas are much taller than the Hottentots of the colonies, though they appeared evidently to be descended from the same race, having the same language and customs with their neighbours the NIMIQUAS (see that article), who are certainly of Hottentot extraction.

As the excessive dryness of the country renders springs very rare, the Koraquas would be unable to inhabit it, had they not found the means of remedying this scarcity of water. For this purpose they dig in the earth a kind of cisterns or rather wells, to which they descend gradually by steps; and these people are the only African nation among whom our author ever found the same mark of industry.

As their wells always contain little water, and as none is to be lost, they take care to secure it even from the birds, by closing up the mouth of the hole with stones and the branches of trees; so that, unless one knows the spot, it is impossible to find it. They go down into it every day, to fetch up as much water as may be necessary for the consumption of their people and cattle. They draw it in a kind of vessels made of hollowed wood, and pour it into the skins of buffaloes or giraffes, placed in a concave form on the ground to hold it; but they distribute it with the utmost parsimony, and never draw more than they absolutely have occasion for.

Notwithstanding this strict economy, the wells often become dry; and in that case the horde is obliged to remove to some other place. Among all the western tribes, therefore, there are none who lead so wandering a life as the Koraquas: the consequence of which is, that, as they often change their abode, and acquire new neighbours, they must, in some measure, adopt the customs of the nations near which they fix their residence. Some tribes of them grease themselves like the Hottentots; while others tattoo their face, breast, and arms, after the manner of the Caffres. It is, however, to be remarked, that the same colour is not employed by all the Koraquas; each has his own, according as caprice may direct him in his choice, and it generally varies every day; which renders, as one may say, the inhabitants of the same horde strangers to each other, and gives them a motley appearance, as if they were dressed for a masquerade.

Krishna. KRISHNA or CRISNA, is an eastern river of considerable magnitude, which is very little known in Europe. We have the following account of it, and its tributary waters, and the countries through which it flows, in Mr Pennant's View of Hindustan:

"From Gangapatam, on the northern mouth of the Pennar, the land runs due north as far as Mottapilli, when it forms a strong curve toward the east; the point of which is one side of the great river Crisna, in about lat. 15° 43'. Its Delta, which winds round as far as Masulipatam, is not considerable. This river annually overflows a vast tract of country, like the Indus on the western side of this empire, and like all the other great rivers on this extensive coast. The Crisna rises from the foot of the western Ghauts, and not more than 45 miles from Severndrug, on the western coast. There is another branch to the east, that rises still more northerly. On that side is Sattara, a strong fortress, the capital of the Mahratta state in the time of the rajahs of Sivaji's race. It was taken by him in 1673, and found to be the depository of immense treasure; at that time it belonged to the king of Vijapur: it was afterwards used by the Mahrattas as the lodgment of their riches, and also as a retreat for the more defenceless inhabitants of Puna, and other open towns, in time of potent invasions.

"The river continues descending to the east. In latitude 17° is Meritch, a strong fortress, with a Jaghirdar territory, conquered from its owner by Hyder. In lat. 16° 45', a small river discharges itself into the Crisna from the north. It would not be worth mentioning, but that Pannela, a fortress of vast strength, was made by Sumbuji, the profligate son of Sivaji, his residence just before his surprisal in 1689, betrayed by Cablis Khan, the vile instrument of his pleasures corrupted by Aurengzebe. His extravagant love of women brought on him ruin. Informed by Cablis that a Hindu of rank and great beauty was on the road to be delivered by her parents to her husband, according to the custom of the Hindus, he instantly put himself at the head of a small body of horse to carry off the prize, and ordered Cablis to follow at a distance for his protection, in case of accidents in that hostile time. The traitor had given notice to Aurengzebe of this expedition, who, sending a body of cavalry, surprised Sumbuji just as he had dispersed the nuptial procession.

"Into the north side of the Crisna, in lat. 16° 25', falls the great river Bima, after a course of 350 miles. It rises at the head of the western Ghauts, parallel to Chaul in the Concan, and not above 50 miles from the sea. It descends rapidly towards the south-east. In lat. 17° 40' it receives a small river from the west, on the southern banks of which stands Vijapur, the capital of the famous kingdom of the same name, now possessed by the Mahrattas, but once governed by its own monarchs, till conquered by Aurengzebe in 1686. It was of great extent, and reached to the western sea, where it possessed the ports of Dabul, Vingorla, and Carapatan.

"The capital Vijapur is some leagues in circuit, seated in a fine but naked country, well watered. It makes a singular appearance from an adjacent eminence, filled with numbers of small domes, and one of a majestic size.

size. It was once a city of great splendour, and filled with palaces, mosques, mausoleums, and public and private buildings of great magnificence; many of them are fallen to ruin, and give melancholy proofs of its former splendour. I shall not attempt to detail them. The palaces of the kings, and accommodations for their attendants, were within a vast fort, surrounded with a ditch 100 yards wide; the depth appeared to be great, but is now filled with rubbish: within the fort is the citadel. Tavernier says, that the great ditch was filled with crocodiles, by way of garrison, to prevent all access by water. Lieutenant Moor has his doubts about this, imagining that there never was any water in this fosse. That such garrisons have existed I doubt not. I have read in Purchas, that in Pegu the fosses of fortified places were stocked with those tremendous animals, not only to keep out enemies, but to prevent desertion. This practice has certainly been of great antiquity in some parts of India: Pliny mentions it as used in a fair city of the Horatæ, a people I cannot trace.

"The Crisna, above and below its conflux with the Bima, is fordable; and a few miles below its channel is 600 yards wide, made horrid with the number and rudeness of the variously formed rocks, which are never covered but in the rainy season.

"The Tungbuddra is another vast branch of the Crisna. It falls into it in lat. 16° 25', and originates extremely south, from a doubtful fountain. Towards its lower part it divides into three or four small branches, which rise remote from each other; the most southern is the Curga Nair's country; the most northern from the head of the Ghauts opposite to Onor, and scarcely 20 miles from the sea. What must give this river great celebrity, is its having had on its banks, in lat. 15° 22', the splendid city of Vijanagar. Ferishta says, that it was founded in 1344 by Belaldeo king of the Carnatic, which in those days included the whole peninsula. It was visited by Cæsar Frederick a Venetian traveller, in 1565, and found deserted and ruinous; having been sacked by four confederated Mahomedan princes two years before, on which its monarch had retired to Penuconda. Frederick says that its circumference was 24 miles. Mr Rennel has given us a view of its present state from Lieutenant Emitt, who visited it in 1792.

"The ruins of Vijanagar are in the little Sircar of Anagundi, which does not extend above 20 miles around this vast city. It is very singular, that that little Sircar is now possessed by a lineal descendant of Rama Rajah, the last great monarch of Vijanagar, and its attendant nations Canarine and Malabar, united 700 years before under the rule of Crisna Deva. Tippu wished to reserve this little tract to himself, for the satisfaction of generously restoring to the descendant the small relique of the great empire of his ancestors. He is denied the title of Rajah, instead of which he has the diminutive Rail bestowed on him. This is suitable to his revenues, which do not exceed two lacs of rupees, or 25,000 *per annum*, with the empty regality of a mint at Anagundi." In the remainder of its course the Crisna offers nothing remarkable.

KUARA, is a beautiful tree, which grows in the south and south-west parts of Abyssinia. With the ebony it is almost the only wood of the province of Kuara, of which it bears the name; but Mr Bruce assures us, that it is very frequent in all the countries where there is gold. "It is (says he) what naturalists call *a Corallodendron*, probably from the colour of its flowers or of its fruit, both equal in colour to coral. Its fruit is a red bean, with a black spot in the middle of it, which is inclosed in a round capsula or covering, of a woody nature, very tough and hard. This bean seems to have been in the earliest ages used for a weight of gold among the Shangalla, and, where that metal is found, all over Africa; and by repeated experiments, I have found that, from the time of its being gathered, it varies very little in weight, and may perhaps have been the very best choice that therefore could have been made between the collectors and buyers of gold.

"I have said this tree is called kuara, which signifies the sun. The bean is called *carat*, from which is derived the manner of esteeming gold as so many carats fine. From the gold country in Africa it passed to India, and there came to be the weight of precious stones, especially diamonds; so that to this day in India we hear it commonly spoken of gold or diamonds, that they are of so many carats fine or weight. I have seen these beans likewise from the West-Indian islands. They are just the same size, but, as far as I know, are not yet applied to any use there."

This is a very different account of the origin of the term CARAT from what we have given in the *Encyclopædia*; but the reader will judge for himself between the two.

KUMI, the name of an island between Japan and China, of which Perouse writes in the following terms: "On the 5th of May, at one o'clock in the morning, we made an island, which bore north north east of us; we passed the rest of the night, standing off and on, under an easy sail, and at day-break I shaped my course so as to run along the west coast of this island, at the distance of half a league. We sounded several times without finding bottom. We were soon satisfied that this island was inhabited, for we saw fires in several places, and herds of oxen grazing on the sea-shore. When we had doubled its west point, which is the most beautiful and best inhabited side, several canoes put off from the shore in order to observe us. They seemed to be extremely in fear of us; their curiosity caused them to advance within musket shot, and their distrust made them immediately flee away with speed. Our shouts, gestures, signs of peace, and the sight of some stuffs, at length determined two of the canoes to come alongside of us. I made each of them a present of a piece of nankeen and some medals. It was evident that these islanders had not left the coast with any intention of trafficking with us, for they had nothing to offer in exchange for our presents; they only fastened to a rope a bucket of fresh water, making signs to us, that they still thought themselves in our debt, but that they were going ashore to fetch provision, which they expressed by putting their hand into their mouth. Before coming alongside the frigate, they placed their hands upon their breast, and raised their arms towards the sky: these gestures were repeated by us, and then they resolved to come on board; but it was with a want of confidence, which was strongly expressed in their countenance during the whole time. They nevertheless invited us to approach the land, giving us to understand, that we should there want for nothing. These islanders are

are neither Japanese nor Chinese, but, situate between these two empires, they seem to partake of both people. Their covering was a shirt and a pair of cotton drawers. Their hair, tucked up on the crown of the head, was rolled round a needle, which seemed to us to be gold: each of them had a dagger, the handle of which was gold also. Their canoes were made out of hollowed trees, and they managed them very indifferently. I could have wished to land upon this island, but as we had brought the ship to, in order to wait for these canoes, and as the current set to the northward with extreme rapidity, we had drifted a great way to leeward, and our efforts to reach it would perhaps have been in vain: besides, we had not a moment to lose, and it was of the highest importance to us to get out of the Japan seas before the month of June; a period of storms and hurricanes, which render these seas the most dangerous in the whole world.

"It is clear, that vessels which might be in want would readily provide themselves with provision, wood, and water, in this island, and perhaps even carry on a little trade; but as it is not more than three or four leagues in circumference, there is no great probability that its population exceeds four or five hundred persons; and a few gold needles are not of themselves a proof of wealth." Our author, by observation, found the latitude of Kumi to be 24° 33′ north; its longitude 120° 56′ east from Paris.

KURILES, are a cluster of islands, of which some account has been given under the word KURILI in the *Encyclopædia*. In addition to that article, the following particulars are worthy of notice: Of the 21 islands belonging to Russia, which are distinguished from each other, not by names, but by numbers, four only are inhabited, viz. those which are called the first, the second, the thirteenth, and the fourteenth. The last two may indeed be counted only as one, because the inhabitants all pass the winter upon N° 14, and return to N° 13 to pass the summer months. The others are entirely uninhabited, the islanders only landing there occasionally from their canoes for the sake of hunting foxes and otters. Several of these last mentioned islands are no better than large rocks; and there is not a tree on any one of them. The currents are very violent between the islands, particularly at the entrance of the channels, several of which are blocked up by rocks on a level with the sea. The population of the four inhabited islands amounts at most to 1400 souls. The inhabitants are very hairy, wear long beards, and live entirely upon seals, fish, and the produce of the chace. When visited by M. Perouse, they had just been exempted for ten years from the tribute usually paid to Russia, because the number of otters on their islands is very much diminished. These poor people are good, hospitable, and docile, and have all embraced the Christian religion. The more southern and independant islanders sometimes pass in canoes the channels that separate them from the Russian Kuriles, in order to give some of the commodities of Japan in exchange for peltries.

L.

Labdasseba. LABDASSEBA, a tribe of savage Arabs, who inhabit the desart of Sahara in Africa. They are the most powerful of all those tribes except the Ouadelims; and they resemble these so much in every thing, that we shall give an account of the manners of both under the title OUADELIMS, and of their country under that of SAHARA.

LABORATORY, is an apparatus so necessary to the chemist, that every contrivance to render it more convenient, or to lessen the expence of it, must contribute greatly to the advancement of science. The abilities of *Morveau* alias *Guyton*, and the success with which he has prosecuted the study of chemistry, are well known; and therefore his different methods of saving time and expence in making chemical experiments must be worthy of the notice of younger chemists.

In the second volume of the Memoirs of the Ancient Academy of Dijon, we have a description by him of a box containing a kind of portable laboratory, composed of a lamp with three wicks, disposed in the figure of an equilateral triangle, to form an internal current of air, with supports for the different vessels of digestion, distillation, evaporation, &c. He made a solution of silver with common aqua fortis and the metal in an alloyed state, which answered very well as a re-agent, without having occasion for any other utensils but this box and apothecary's phials, which are every where to be found.

This apparatus, however, was confined in its application, and he soon thought of improving it. He constructed a lamp, on the principles of Argand, with three concentric circular wicks, each having an interior and exterior current of air. The effect surpassed his expectations with regard to the intensity of the heat; but it was difficult to prevent the destruction of the hard solder round the wicks; and the glass retorts were frequently melted at the bottom, and disfigured. It was attended with other inconveniences, and the quantity of oil consumed was great.

A short time afterwards, it occurred him to substitute, instead of the glass chimney of Argand's lamp, a cylinder of copper with an indented part or ledge a few millimetres (see REVOLUTION, *Encycl.* n° 183.) above the flame, to perform the office of the indented chimney of glass, and by that means to render it practicable to raise the wick to a certain height without smoaking. This cylinder has three branches like a chaffing-dish. By this apparatus two or three decilitres of water (about half an English wine pint) may be brought to boil in a copper or glass vessel in about six or seven minutes. It has served for a number of operations; but it was not till after he had observed the degree of heat obtained from the lamp in its ordinary state, and particularly since he had substituted instead of the metallic tube a chimney of glass cut off at the length of three

Laboratory.

centimetres (rather more than one English inch) above the contraction, that he perceived all the advantages it was capable of affording; and that by means of a moveable support for the reception of the different vessels, which may be fixed at pleasure by a thumb-screw, this lamp furnace, at the same time that it gives light, and consequently without any additional expence, may with facility be used for almost every one of the operations of chemistry; such as digestions, solutions, crystallizations, concentrations; the rectification of acids; distillations on the sand-bath, or by the naked fire; incinerations of the most refractory residues; analyses with the pneumatic apparatus, or of minerals by the saline fusion, &c. "I have not (says he) hitherto met with any exception but for complete vitrifications and cupellations; for even the distillations to dryness may be performed with some precautions, such as that of transferring the matter into a small retort blown by the enameller's lamp, and placing its bottom on a little sand-bath in a thin metallic dish." The support here mentioned is simply a copper ring eight centimetres (3,15 inch.) in diameter, which is raised or lowered by sliding on a stem of the same metal. Nothing more was required but to adapt it to the square iron stem which passes through the reservoir of the lamp. The connection is made by a piece of wood, in order that less of the heat might be dispersed. As the lamp itself is capable of being moved on its stem, it is easy to bring it nearer or remove it at pleasure from the vessels, which remain fixed; a circumstance which, independent of the elevation or depression of the wick, affords the means of heating the retorts by degrees, of moderating or suppressing the fire instantly, or of maintaining it for several hours at a constant or determinate intensity, from the almost insensible evaporation of crystallizable solutions to the ebullition of acids; properties never possessed by the athanor, of which chemists have boasted so much. The advantage of these will be properly valued by those operators who know that the most experienced and the most attentive chemists meet with frequent accidents, by which both their vessels and the products of their operations are lost for want of power in the management of the fire."

For the analysis of stones, such as the crystals of tin, the shortened chimney of glass is to be used; and the process is to be begun by placing the mixture in a capsule of platina or silver $2\frac{1}{4}$ inches in diameter. This capsule is to be placed on the support, and the heat regulated in such a manner, that ebullition shall take place without throwing any portion of the matter out of the vessel. As soon as its contents are perfectly dry, they are to be transferred into a very thin crucible of platina, of which the weight is about $252\frac{1}{2}$ grains English, and its diameter one inch and three-fourths. This crucible rests on a small support of iron-wire, which serves to contract the ring; and the wick being at its greatest elevation, with the ring lowered to the distance of $9\frac{1}{4}$ inches from the upper rim of the chimney, Guyton produced, in less than twenty minutes, the saline fusion to such a degree, that from the commencement of the operation the decomposition proceeded as far as to 0.70 of the mineral. The same apparatus, that is to say, with the shortened chimney, serves for oxidations, incinerations, torrefactions, and distillations to dryness.

In such operations as require a less heat, he leaves the lamp with its large chimney absolutely in the same state as when it is used for illumination; and by raising and lowering either the ring which supports the vessel, or the body of the lamp if the vessels be fixed in communication with others, he graduates the heat at pleasure. Vinegar distils without interruption at $2\frac{1}{4}$ inches English from the upper termination of the chimney, that is to say, $7\frac{1}{4}$ inches English from the flame. Water is made to boil in eight minutes, at the same height, in a glass vessel containing one wine pint English, and is uniformly maintained at the distance of $8\frac{1}{4}$ inches from the flame.

"I must not in this place (says our author) omit to mention a slight observation which this process has afforded, because it may lead to useful applications, and tends to point out one great advantage of this method of operating; namely, that an infinity of circumstances may be perceived, which might not even be suspected when the whole process is carried on within a furnace. I have remarked, as did likewise several of my colleagues who were then present, that a column of bubbles constantly rose from a fixed point of the retort on one side of the bottom. We were of opinion, that some particle of matter was in that place incorporated with the glass, which had a different capacity for heat from that of the rest of the glass. In order to verify this conjecture, I endeavoured the following day to distil the same quantity of the same water in the same retort, after having introduced a button of cupelled silver, weighing nine decigrammes (20½ grains). At the commencement of the operation there was a small stream of bubbles from the same point as before; but a short time afterwards, and during the whole remaining time of operating, the largest and most incessant stream of bubbles rose from the circumference of the button, which was often displaced by the motion; and in proportion to the time the product of the distillation was sensibly greater. Whence we may conclude, that metallic wires or rods, distributed through a mass of water required to be kept in a state of ebullition, and placed a little below its surface, would produce, without any greater expence of fuel, nearly the same effect as those cylinders filled with ignited matter which are made to pass through the boilers."

We have related this fact in Guyton's own words, or at least in a faithful translation of them; and we are far from calling it in question, for it is a fact which has been often observed; but we think his inference from it too hastily drawn. It is not conceivable, that heat can be more rapidly conveyed through a mass of liquid by the conducting power of metal, than by a free circulation; but we agree with what seems to be Mr Nicholson's opinion *, that the thin stratum of water beneath the button becomes more suddenly and violently elastic than elsewhere, and therefore rises regularly to the surface. The whole of this phenomenon the reader will find explained in our article STEAM (*Encycl.*), n° 10. But this is a digression.

We return therefore to Guyton's laboratory, of which the reader will form a distinct notion from plate XXXIII. where fig. 1. represents the whole apparatus ready mounted for distillation, with the tube of safety and a pneumatic receiver. A is the body or reservoir of the usual lamp of Argand, with its shade and glass chimney. The lamp may be raised or lowered at pleasure by means of the thumb screw B, and the wick rises

* *Journal*, August 1798, note, page 212.

and falls by the motion of the small toothed wheel placed over the waste cup. This construction is most convenient, because it affords the facility of altering the position of the flame with regard to the vessels, which remain fixed; and the troublesome management of bended wires above the flame for the support of the vessels is avoided, at the same time that the flame itself can be brought nearer to the matter on which it is intended to act. D, a support consisting of a round stem of brass, formed of two pieces which screw together at about two-thirds of its height. Upon this the circular ring E, the arm F, and the nut G slide, and are fixable each by its respective thumb screw. The arm also carries a moveable piece H, which serves to suspend the vessels in a convenient situation, or to secure their position. The whole support is attached to the square iron stem of the lamp by a piece of hard wood I, which may be fixed at any required situation by its screw. K represents a stand for the receivers. Its moveable tablet L is fixed at any required elevation by the wooden screw M. The piece which forms the foot of this stand is fixed on the board N; but its relative position with regard to the lamp may be changed by sliding the foot of the latter between the pieces OO. P, another stand for the pneumatic trough. It is raised or lowered, and fixed to its place, by a strong wooden screw, Q. R is a tube of safety, or reversed syphon, which serves, in a great measure, to prevent the bad effects of having the vessels either perfectly closed, or perfectly open. Suppose the upper bell-shaped vessel to be nearly of the same magnitude as the bulb at the lower end of the tube, and that a quantity of water, or other suitable fluid, somewhat less than the contents of that vessel, be poured into the apparatus. In this situation, if the elasticity of the contents of the vessels be less than that of the external air, the fluid will descend into the bulb, and atmospheric air will follow and pass through the fluid into the vessels; but, on the contrary, if the elasticity of the contents be greater, the fluid will be either sustained in the tube, or driven into the bell-shaped vessel; and if the force be strong enough, the gaseous matter will pass through the fluid, and in part escape.

Fig. 2. Shews the lamp furnace disposed to produce the saline fusion; the chimney of glass shortened; the support D turned down; the capsule of platina or silver S placed on the ring very near the flame.

Fig. 3. The same part of the apparatus, in which, instead of the capsule, a very thin and small crucible of platina T is substituted, and rests upon a triangle of iron wire placed on the ring.

Fig 4. Exhibits the plan of this last disposition.

LACERTA, in astronomy. See ASTRONOMY, n° 406. *Encycl.*

LACMUS, a dye stuff prepared by the Dutch from the LICHEN ROCELLA, which see in this *Supplement*.

LACSHA, the Indian name of the lac insect, which has been described in the *Encyclopædia* under the title COCCUS, *Species* 5. Since that article was published, a description of that insect, which is more to be depended upon, has been given to the world in the second volume of the Asiatic Researches. It is by Mr Roxburgh, surgeon on the Madras establishment, and was communicated to the Society by Dr James Anderson physician at Fort St George, who observes, that Mr Roxburgh's discovery will bring the lacsha as a genus into the class *Hemiptera* of Linnæus.

"Some pieces of very fresh-looking lac (says Mr Roxburgh) adhering to small branches of mimosa cinerea, were brought me from the mountains on the 20th of November 1789. I kept them carefully, and today, the 4th of December, fourteen days from the time they came from the hills, myriads of exceedingly minute animals were observed creeping about the lac and branches it adhered to, and more still issuing from small holes over the surface of the cells: other small and perforated excrescences were observed with a glass amongst the perforations, from which the minute insects issued, regularly two to each hole, and crowned with some very fine white hairs. When the hairs were rubbed off, two white spots appeared. The animals, when single, ran about pretty briskly, but in general they were so numerous as to be crowded over one another. The body is oblong, tapering most towards the tail, below plain, above convex, with a double, or flat margin: laterally on the back part of the thorax are two small tubercles, which may be the eyes: the body behind the thorax is crossed with twelve rings: legs six; feelers (antennæ) half the length of the body, jointed, hairy, each ending in two hairs as long as the antennæ: rump, a white point between two terminal hairs, which are as long as the body of the animal. The mouth I could not see. On opening the cells, the substance that they were formed of cannot be better described, with respect to appearance, than by saying it is like the transparent amber that beads are made of: the external covering of the cells may be about half a line thick, is remarkably strong, and able to resist injuries: the partitions are much thinner: the cells are in general irregular squares, pentagons and hexagons, about an eighth of an inch in diameter, and one quarter deep: they have no communication with each other. All those I opened during the time the animals were issuing, contained in one half, a small bag filled with a thick red jelly like liquor, replete with what I take to be eggs: these bags, or utriculi, adhere to the bottom of the cells, and have each two necks, which pass through perforations in the external coat of the cells, forming the fore-mentioned excrescences, and ending in some very fine hairs. The other half of the cells have a distinct opening, and contain a white substance, like some few filaments of cotton rolled together, and numbers of the insects themselves ready to make their exit. Several of the same insects I observed to have drawn up their legs, and to lie flat: they did not move on being touched, nor did they shew any signs of life with the greatest irritation.

"*December* 5. The same minute hexapedes continue issuing from their cells in numbers: they are more lively, of a deepened red colour, and fewer of the motionless sort. To-day I saw the mouth: it is a flattened point about the middle of the breast, which the little animal projects on being compressed.

"*December* 6. The male insects I have found to-day: a few of them are constantly running among the females most actively: as yet they are scarce more, I imagine, than one to 5000 females, but twice their size. The head is obtuse; eyes black, very large; antennæ clavated, feathered, about ⅔ds the length of the body: below the middle an articulation, such as those in the legs: colour between the eyes a beautiful shining green: neck very short: body oval, brown: abdomen oblong, the length of body and head: legs six: wings membranaceous, four, longer than the body, fixed to the sides of the

the thorax, narrow at their growing broader for ⅔ds of their length, then rounded the anterior pair is twice the size of the posterior: a strong fibre runs along their anterior margin they lie flat, like the wings of a common fly when it walks or rests; no hairs from the rump: it springs most actively to a consider able distance on being touched: mouth in the under part of the head: maxillæ transverse. To day the female insects continue issuing in great numbers, and move about as on the 4th.

"*December 7.* The small red insects still more numerous, and move about as before: winged insects, still very few, continue active. There have been fresh leaves and bits of the branches of both *Mimosa Cinerea* and *Corinda* put into the wide mouthed bottle with them: they walk over them indifferently, without shewing any preference, or inclination to work or copulate. I opened a cell whence I thought the winged flies had come, and found several, eight or ten, more in it, struggling to shake off their incumbrances: they were in one of those utriculi mentioned on the 4th, which ends in two mouths, shut up with fine white hairs, but one of them was open for the exit of the flies; the other would no doubt have opened in due time: this utriculus I found now perfectly dry, and divided into cells by exceeding thin partitions. I imagine, before any of the flies made their escape, it might have contained about twenty. In these minute cells with the living flies, or whence they had made their escape, were small dry dark coloured compressed grains, which may be the dried excrements of the flies."

LAMANON (Robert Paul), of the academy at Turin, correspondent of the Academy of Sciences at Paris, and member of the Museum in the same city, was born at Salon in Provence, in 1752, of an old and respectable family. Being a younger son, he was destined for the church, and sent to Paris to complete his theological studies; but getting acquainted with the philosophers (as they called themselves), he soon lost all relish for the study of theology, and devoted himself to the physical sciences, especially those of chemistry and mineralogy. Into the church, however, he got, and rose to the dignity of canon; but by the death of his father and elder brother, having acquired the right of directing his own future exertions, he hastened to quit a profession, towards which he felt no partiality.

A prelate, then in high favour at court, hearing of Lamanon's intention of quitting his office of canon, offered him a considerable sum, to induce him to resign in favour of one of his dependents. The chapter of Arles, replied our young ecclesiastic, did not sell me my benefice, I shall therefore restore it in the same manner that I received it. This conduct was certainly meritorious; and his eulogist *Ponce* mentions another trait of his character, which sets him in a very amiable point of view; he refused to accept of his paternal inheritance, otherwise than as an equal sharer with his brothers and sisters.

Thus liberated from the trammels of his former profession, Lamanon applied himself with uncommon ardour to study. Eager to raise the awful veil that conceals from our eyes the secrets of nature; persuaded, that even the greatest genius only amuses itself with false systems in the silence of a cabinet; convinced of the necessity of much and various observation, and of surprising Nature, as it were, in the very fact, in order to penetrate into the sublimity of her operations; our young philosopher travelled through Provence and Dauphine, and scaled the Alps and Pyrenees. At the sight of these vast natural laboratories the bent of his mind burst forth instantaneously: he climbed to the summit of rocks, and explored the abyss of caverns, weighed the air analysed specimens, and, in his ardent fancy, having attained the secrets of creation, he formed a new system of the world. On his return home, he applied with additional interest to the study of meteorology, mineralogy, natural philosophy, and the other branches of the history of nature.

Lamanon.

Whilst he was meditating a visit to Paris for the purpose, as his eulogist expresses himself, of conversing with the luminaries of science, the inhabitants of the commune of Salon, having lost a cause against their lord, unanimously elected Lamanon, with whose integrity and abilities they were well acquainted, to go and solicit of the council the repeal of an unjust decree that had been obtained by partiality. The reply of the young philosopher on this occasion is an additional proof of his uncommon disinterestedness. "As I intend (said he) to go to Paris on business of my own, I cannot think of accepting your offer of 24 livres daily pay: a twelfth of this sum will cover the extraordinary expences of the journeys that I shall be obliged to make to Versailles on your account." He had the satisfaction of complete success in the business thus undertaken.

Having satisfied his curiosity in Paris, he went over to England. During the passage, though much incommoded by sea-sickness, and in imminent hazard of being overwhelmed by the tumbling waves of a very stormy sea, he caused himself to be tied to the main-mast, in order to contemplate at leisure so grand and fearful a spectacle. The bursts of thunder, the howling of the wind, the brilliancy of the lightning, the glancing of the spray which covered him every moment, these objects, so terrible to an ordinary man, threw him into a kind of mental intoxication, and he has often declared, that this day was the most exquisite of his whole life.

Convinced that the friendship of an eminent man elevates the soul, excites generous emulation, and becomes an additional stimulus to one whose delight is study, and whose most pressing want is an object on which to place his affection, Lamanon anxiously endeavoured to merit the regard of CONDORCET, so well known by his talents, his impieties, his rebellion, and his misfortunes. This academician, justly considering that an apostate priest would be ready to join the conspiracy of the philosophists against the altar and the throne, received Lamanon with distinction, and at length admitted him to his most intimate friendship.

During the three successive years that Lamanon spent at Paris, he followed with care the track of those learned societies, of which he had been elected a member. He became at this period, together with Count de Gebelin, and some other philosophers and artists, one of the founders of the Museum, the greater part of the members of which are now reunited in the open society of sciences, letters, and arts, at Paris. Among the different papers of his that were read at various meetings of these societies, Ponce mentions with particular approbation what he calls *a notice* of Adam de Crapone, an eminent hydraulic engineer; a memoir on the Cretins; a memoir on the theory of the winds; a treatise on the alteration in the course of rivers, particularly the Rhone; and another on an enormous bone belonging

to

Lamanon. to ſome cetaceous fiſh, that was dug up at Paris in laying the foundations of a houſe in the *rue Dauphine*. We have not ſeen theſe memoirs; but as their author was the friend of Condorcet, and fancied that he had attained the ſecrets of creation, we can eaſily conceive their tendency.

Having reſolved again to reviſit Switzerland and Italy, Lamanon firſt went to Turin, where he allied himſelf to the learned of that country. During his ſtay there, the brilliant novelty diſcovered by Montgolfier was occupying the attention of all the philoſophers of Europe. Lamanon, deſirous of making ſome experiments of this kind himſelf, aſcended in a balloon from the city of Turin; but not perceiving in this diſcovery, which had at firſt highly intereſted him, an object of public utility; not foreſeeing, that one day, on the plains of Fleurus, it would be the cauſe of rallying and eſtabliſhing victory under the ſtandards of France, he returned to his favourite occupations. Purſuing his route from Piedmont, he viſited Italy, and returned by Switzerland, where he explored the Alps and aſcended the ſummit of Mont Blanc; thence returning, loaden with the ſpoils of the countries which he had traverſed, to Provence, he employed himſelf in the arrangement of the intereſting fruits of his journey.

Of the ſcrupulous exactneſs of his obſervations, his eulogiſt gives the following inſtance: "Being convinced that the plain of Crau, divided by the channel of the Durance, had formerly been a lake, he wiſhed to be abſolutely aſſured of it. For this purpoſe he collected a ſpecimen of each of the ſtones that are to be found in this vaſt plain; the number of theſe he found to amount to nineteen; then tracing the courſe of the river towards its head, near the frontiers of Savoy, he obſerved, that above each junction of the tributary ſtreams with the Durance, the variety of pebbles diminiſhed. Afterwards aſcending the current of each of theſe ſmaller ſtreams, he diſcovered on their banks the original rock of every pebble that overſpreads the plain of Crau; thus inconteſtably proving, that this plain was anciently a lake formed by the waters of the Durance, and the ſtreams that fall into it. If all philoſophers (ſays our author) would conduct their examinations with equal preciſion, certain hypotheſes, more brilliant than ſolid, would not find ſo many admirers; the charm of imagination, and the graces of ſtyle, would not ſo often encroach upon the impreſcriptible rights of nature and truth."

To citizen Ponce this appears a demonſtration of Lamanon's theory; but we cannot ſay that it does ſo to us. It may be a kind of proof, though not a demonſtration, that in ſome convulſion of nature, ſtones had been rolled from the rock, and the plain of Crau, for a time, overflowed by the Durance; but it ſurely furniſhes no evidence of that plain's having ever been *a permanent lake*. It *may* have been ſo; but ſuch inveſtigations as this will not guard philoſophers againſt the deluſions of favourite hypotheſes.

It was at the time when Lamanon was preparing for the preſs his great work on the *Theory of the Earth*, that the French government conceived the vaſt project of completing the diſcoveries of Captain Cook: the academy of ſciences was entruſted with the care of ſelecting men capable of rectifying our notions of the ſouthern hemiſphere, of improving hydrography, and advancing the progreſs of natural hiſtory. Condorcet, not knowing any one better qualified for this laſt department than Lamanon, wrote to him an invitation to ſhare the danger and glory of this great enterprize. He accepted with eager tranſport a propoſal that fulfilled his higheſt expectations, haſtened to Paris, refuſed in a conference with the miniſter the ſalary that was offered, took a haſty leave of his friends, and departed for Breſt.

Lamanon, Lamp.

On the 1ſt of Auguſt 1785, the armament ſet ſail under the orders of La Perouſe, an experienced commander, whoſe patriotiſm and ſcientific zeal were equal to his courage and good ſenſe, and who had already merited the public confidence. The philoſophers of all Europe were in expectation of thoſe uſeful diſcoveries, the probable fruit of the zeal and talents employed in the expedition. The beginning of the voyage was proſperous. After various delays, and a multitude of obſervations, the two veſſels arrived at the iſland of Maouna, one of the ſouthern Archipelago. The impatient Lamanon, eager to aſſure himſelf of the truth of the publiſhed accounts of that country, debarked with Langle, the ſecond in command. At the moment of their return, the natives, in hopes of booty, which had been excited by the number of preſents that they had received, ſeized upon the boats, and attacked the party. The French were obliged to have recourſe to arms for ſelf defence, and a deſperate combat enſued. Lamanon, Langle, and ten of the two boats crews, fell a ſacrifice to the fury of theſe barbarians.

Thus periſhed Lamanon, a young man ardent in the purſuits of ſcience, to a high degree diſintereſted, and a zealot in what he thought the cauſe of liberty. He refuſed the ſalary which was allotted to him when he was appointed to this unfortunate expedition; for "if I do not feel ſatisfied (ſaid he) on board the veſſel; if my inclination or curioſity lead me to quit the ſhip, — I ſhould be unhappy if any power in the world had acquired the right of preventing me."

According to M. Ponce, Lamanon ſeemed born to bring about a revolution in ſcience: the depth of his ideas, the energy of his character, the ſagacity of his mind, united to that lively curioſity that can draw inſtruction out of any thing, and leaves nothing unexplored, would have led him to the moſt valuable diſcoveries. In perſon he was tall; and to great vivacity and expreſſion of feature added prodigious ſtrength and activity; in a word, Nature formed him with ſuch care, as if ſhe had intended him for one of thoſe few who are deſtined to great exploits. His ſtyle was nervous, often poetical, without loſing ſight of propriety, and the language of ſentiment might frequently be diſcovered in the midſt of ſtrong and ſtriking expreſſions; and if he wanted the exquiſitely dazzling poliſh of diction, he was eminently gifted with the preciſion of logical reaſoning, which commands attention and enforces perſuaſion.

LAMP (see *Encycl.*) is an inſtrument compriſing three articles which demand our attention, viz. the oil, the wick, and the ſupply of air. It is required that the oil ſhould be readily inflammable, without containing any fetid ſubſtance which may prove offenſive, or mucilage, or other matter, to obſtruct the channels of the wick. Mr Nicholſon ſays*, that he knows of no proceſs by which oils can be meliorated for this purpoſe, except that of waſhing with water containing acid or alkali. Either of theſe is ſaid to render the mucilage of animal oils more ſoluble in water; but acid is to be preferred, becauſe

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because it is less disposed to combine with the oil itself. Perhaps oil might be deprived of all fetid smell in burning, by being made to pass through Collier's filtering apparatus, described under the word FILTER in this *Suppl.*

The office of the wick appears to be chiefly, if not solely, to convey the oil by capillary attraction to the place of combustion. As the oil is consumed and flies off, other oil succeeds, and in this way a continued current of oil and maintenance of the flame are effected. But as the wicks of lamps are commonly formed of combustible matter, it appears to be of some consequence what the nature and structure of this material may be. It is certain that the flame afforded by a wick of rush differs very considerably from that afforded by cotton; though perhaps this difference may, in a great measure, depend on the relative dimensions of each. And if we may judge from the different odour in blowing out a candle of each sort, there is some reason to suspect that the decomposition of the oil is not effected precisely in the same manner in each. We have also some obscure accounts of prepared wicks for lamps, which are stated to possess the property of facilitating the combustion of very impure oils, so that they shall burn for many hours without smoke or smell.

The economical wicks of M. Leger, concerning which a report was presented to the Academy at Paris in 1782 by Condorcet, Lavoisier, and De Milly, were composed of cotton of different sizes and forms, namely, round and flat, according to the use they were intended to serve. They were covered with a fat substance, of a smell not disagreeable, but feebly aromatic. From the trials of these commissaries it was ascertained: 1. That they afforded a clearer flame, with less undulation. 2. That they consumed somewhat less oil; and, 3. That they possessed the remarkable property of affording neither smell nor smoke, however common the oil made use of. When using a lamp with a flat wick, we have ourselves found a piece of clean cotton stocking answer the purpose better than the cotton wicks which are sold in the shops.

The access of air is of the last importance in every process of combustion. When a lamp is fitted up with a very slender wick, the flame is small, and of a brilliant white colour: if the wick be larger, the combustion is less perfect, and the flame is brown: a still larger wick not only exhibits a brown flame, but the lower internal part appears dark, and is occupied by a portion of volatilised matter, which does not become ignited until it has ascended towards the point. When the wick is either very large or very long, part of this matter escapes combustion, and shews itself in the form of coal or smoke. The different intensity of the ignition of flame, according to the greater or less supply of air, is remarkably seen by placing a lamp with a small wick beneath a shade of glass not perfectly closed below, and more or less covered above. While the current of air through the glass shade is perfectly free, the flame is white; but in proportion as the aperture above is diminished, the flame becomes brown, long, wavering, and smoky; it instantly recovers its original whiteness when the opening is again enlarged. The inconvenience of a thick wick has been long since observed, and attempts made to remove it; in some instances, by substituting a number of small wicks instead of a larger; and in others, by making the wick flat instead of cylindrical. The most scientific improvement of this kind, though perhaps less simple than the ordinary purposes of life demand, is the well known lamp of Argand, described in the *Encyclopædia*.

Much has been said of this lamp, and great praise lavished on the inventor. It cannot indeed be denied that it was a very pretty invention, nor have we the slightest wish to detract from the merit of M. Argand; but truth compels us to say, that the same thought had occurred to others as early as to him, and that lamps had been constructed on his principles long before he had published an account of his lamp to the world (A).

Many ingenious men have endeavoured to determine the most economical method of lighting up large halls and workhouses by means of different lamps and candles; and when the expence of tallow and oil is considered, it will be admitted that they could not employ their time in a manner more beneficial to the poor and the industrious. Among others, Count Rumford and M. Hassenfratz have turned their attention to this subject; and the results of their investigations are worthy of notice. To the Count, a method occurred for measuring the relative quantities of light emitted by lamps of different constructions, which is at once simple and accurate. It is as follows:

"Let the two burning lamps, or other lights to be compared, be called A and B; and let them be placed at equal heights upon two light tables, or moveable stands, in a darkened room; let a sheet of clean white paper be equally spread out, and fastened upon the wainscot, or side of the room, at the same height from the floor as the lights; and let the lights be placed over-against this sheet of paper, at the distance of six or eight feet from it, and six or eight feet from each other, in such a manner, that a line drawn from the centre of the paper, perpendicular to its surface, shall bisect the angle formed by lines drawn from the lights to that centre; in which case, considering the sheet of paper as a plane speculum, the one light will be precisely in the line of reflection of the other.

"This may be easily performed, by actually laying a piece of a looking-glass, six or eight inches square, flat upon the paper, in the middle of it; and observing, by means of it, the real lines of reflection of the lights from that plane, removing it afterwards, as soon as the lights are properly arranged. When this is done, a small cylinder of wood, about ¼th of an inch in diameter, and six inches long, must be held in a vertical position, about two or three inches before the centre of the sheet of paper, and in such a manner, that the two shadows of the cylinder, corresponding to the two lights, may be distinctly seen upon the paper.

If these shadows should be found to be of unequal densities, which will almost always be the case, then that light whose corresponding shadow is the densest must be removed farther off, or the other must be brought nearer to the paper, till the densities of the shadows appear to be exactly equal; or, in other words, till the densities of the rays from the two lights are equal *at the surface of the paper*; when, the distances of the lights from

(A) One of these was employed in the college of Glasgow, by the lecturer on chemistry, so long ago as 1766.

from the centre of the paper being measured, the squares of those distances will be to each other as the real intensities of the lights in question at their sources.

If, for example, the weaker light being placed at the distance of four feet from the centre of the paper, it should be found necessary, in order that the shadows may be of the same density, to remove the stronger light to the distance of eight feet from that centre, in that case, the real intensity of the stronger light will be to that of the weaker as 8^2 to 4^2; or as 64 to 16; or 4 to 1; and so for any other distances.

It is well known, that when any quality proceeds from a centre in straight lines in all directions, like the light emitted by a luminous body, its intensity at any given distance from that centre will be as the square of that distance inversely; and hence it is clear, that the intensities of the lights in question, at their sources, must be to each other as the squares of their distances from that given point *where their rays uniting are found to be of equal density.* For, putting x = the intensity of B, if P represents the point where the rays from A and from B meeting are found to be of equal density or strength, and if the distance of A from P be = m, and the distance of B from the same point P = n; then, as the intensity of the light of A at P, is = $\frac{x}{m^2}$, and the intensity of the light of B at the same place = and as it is $\frac{x}{m^2} = \frac{y}{n^2}$ by the supposition, it will be $x : y :: m^2 : n^2$.

That the shadows being of equal density at any given point, the intensities of the illuminating rays must of necessity be equal at that point also, is hence evident, that the total absence of light being perfect blackness, and the shadow corresponding to one of the lights in question being deeper or fainter, according as it is more or less enlightened by the other, when the shadows are equal, the intensities of the illuminating rays must be equal likewise.

In removing the lights, in order to bring the shadows to be of the same density, care must be taken to recede from, or advance towards, the centre of the paper in a straight line, so that the one light may always be found exactly in the line of reflection of the other; otherwise the rays from the different lights falling upon the paper, and consequently upon the shadows, at different angles, will render the experiment fallacious.

When the intensity of one strong light is compared with the intensities of several smaller lights taken together, the smaller lights should be placed in a line perpendicular to a line drawn to the centre of the paper, and as near to each other as possible; and it is likewise necessary to place them at a greater distance from the paper than when only single lights are compared

In all cases, it is absolutely necessary to take the greatest care that the lights compared be properly trimmed, and that they burn clear and equally, otherwise the results of the experiments will be extremely irregular and inconclusive. It is astonishing what a difference there is in the quantities of light emitted by the same candle, when it burns with its greatest brilliancy, and when it has grown dim for want of snuffing. But as this diminution of light is progressive, and as the eye insensibly conform to the quantity of light actually present, it is not always taken notice of by the spectators; it is nevertheless very considerable, in fact, as will be apparent to any one who will take the trouble to make the experiment; and so great is the fluctuation in the quantity of light emitted by burning bodies, lamps, or candles, in all cases, even under the most favourable circumstances, that this is the source of the greatest difficulties which our author met with in determining the relative intensities of lights by the method here proposed.

To ascertain by this method the comparative densities, or intensities, of the light of the moon and of that of a candle, the moon's direct rays must be received upon a plane white surface, at an angle of incidence of about 60°, and the candle placed in the line of the reflection of the moon's rays from this surface; when the shadows of the cylinder, corresponding to the moon's light and to that of the candle, being brought to be of equal density, by removing the candle farther or bringing it nearer to the centre of the white plane, as the occasion may require, the intensity of the moon's light will be equal to that of the candle *at the given distance of the candle from the plane.*

To ascertain the intensity of the light of the heavens, by day or by night, this light must be let into a darkened room through a long tube blackened on the inside, when its intensity may be compared with that of a candle or lamp by the method above described.

The Count, however, has contrived an apparatus for ascertaining the intensity of the sun's light, compared with the light emitted by any artificial illuminator, with much greater accuracy than it can be done by this simple method. That apparatus we shall describe under the title PHOTOMETER in this *Supplement*; and in the mean time we proceed to lay before our readers the results of his experiments as they relate to economy in the production of artificial light.

The brilliancy of Argand's lamp is not only unrivalled, but the invention is in the highest degree ingenious, and the instrument useful for many purposes; but still, to judge of its real merits as an illuminator, it was necessary to know whether it gives more light than another lamp *in proportion to the oil consumed.* This point he determined in the following manner:

[illegible] a lamp [illegible] wick.

Having placed an Argand's lamp, well trimmed, and burning with its greatest brilliancy, before his *photometer*, and over against it a very excellent common lamp, with a riband wick about an inch wide, and which burnt with a clear, bright flame, without the least appearance of smoke, he found the intensities of the light emitted by the two lamps to be to each other as 17956 to 9063; the densities of the shadows being equal when, the Argand's being placed at the distance of 134 inches, the common lamp was placed at the distance of 95,2 inches, from the field of the photometer.

Both lamps having been very exactly weighed when they were lighted, they were now (without being removed from their places before the photometer) caused to burn with the same brilliancy just 30 minutes; they were then extinguished and weighed again, and were found to have consumed of oil, the Argand's lamp $\frac{213}{1152}$, and the common lamp $\frac{81}{1152}$, of a Bavarian pound.

Now, as the quantity of light produced by the Argand's

gand's lamp, in this experiment, is to the quantity produced by the common lamp as 17956 to 9063, or as 187 to 100, while the quantity of oil consumed by the former is to that consumed by the latter only in the ratio of 253 to 163, or as 155 to 100, it is evident that the quantity of light produced by the combustion of a given quantity of oil in an Argand's lamp is greater than that produced by burning the same quantity in a common lamp, in the ratio of 187 to 155, or as 100 to 85.

The saving, therefore, of oil which arises from making use of an Argand's lamp instead of a common lamp, in the production of light, is evident; and it appears, from this experiment, that that saving cannot amount to less than fifteen *per cent*. How far the advantage of this saving may, under certain circumstances, be counterbalanced by inconveniences that may attend the making use of this improved lamp, our author does not pretend to determine.

Of the relative quantities of light emitted by an Argand's lamp and by a common wax

The Count made a considerable number of experiments to determine the relative quantities of light emitted by an Argand's lamp and a common wax candle; and the general result of them is, that a common Argand's lamp, burning with its usual brightness, gives about as much light as nine good wax-candles; but the sizes and qualities of candles are so various, and the light produced by the same candle so fluctuating, that it is very difficult to ascertain, with any kind of precision, what a common wax-candle is, or how much light it ought to give. He once found that his Argand's lamp, when it was burning with its greatest brilliancy, gave twelve times as much light as a good wax candle $\frac{3}{4}$ths of an inch in diameter, but never more.

Of the fluctuations of the light emitted by candles.

To determine to what the ordinary variations in the quantity of light emitted by a common wax candle might amount, he took such a candle, and, lighting it, placed it before the photometer, and over against it an Argand's lamp, which was burning with a very steady flame; and measuring the intensity of the light emitted by the candle from time to time, during an hour, the candle being occasionally snuffed when it appeared to stand in need of it, its light was found to vary from 100 to about 60. The light of a wax-candle of an inferior quality was still more unequal; but even this was but trifling, compared to the inequalities of the light of a tallow candle.

An ordinary tallow-candle, of rather an inferior quality, having been just snuffed, and burning with its greatest brilliancy, its light was as 100; in eleven minutes it was but 39; after eight minutes more had elapsed, its light was reduced to 23; and in ten minutes more, or twenty-nine minutes after it had been last snuffed, its light was reduced to 16. Upon being again snuffed, it recovered its original brilliancy, 100.

4 Of the relative quantities of bees-wax, tallow, olive-oil, rape-oil, and linseed-oil, consumed in the production of light.

In order to ascertain the relative quantities of bees wax and of olive-oil consumed, in the production of light, the Count proceeded in the following manner: Having provided an end of a wax-candle of the best quality, ,68 of an inch in diameter, and about four inches in length, and a lamp with five small wicks, which he had found upon trial to give the same quantity of light as the candle, he weighed very exactly the candle and the lamp filled with oil, and then, placing them at equal distances (forty inches) before the field of the photometer, he lighted them both at the same time; and, after having caused them to burn with precisely the same degree of brightness *just one complete hour*, he extinguished them both, and, weighing them a second time, he found that 100 parts of wax and 129 parts of oil had been consumed.

Hence it appears, that the consumption of bees wax is to the consumption of olive-oil, in the production of the same given quantity of light, as 100 is to 129.

In this experiment no circumstance was neglected that could tend to render the result of it conclusive; care was taken to snuff the candle very often with a pair of sharp scissars, in order to make it burn constantly with the same degree of brilliancy; and the light of the lamp was, during the whole time, kept in the most exact equilibrium with the light of the candle, which was easily done by occasionally drawing out a little more or less, one or more of its five equal wicks. These wicks, which were placed in a right line, perpendicular to a line drawn from the middle wick to the middle of the field of the photometer, were about $\frac{1}{10}$th of an inch in diameter each, and $\frac{1}{4}$th of an inch from each other; and, when they were lighted, their flames united into one broad, thin, and very clear, white flame, without the least appearance of smoke.

In order to ascertain the relative consumption of olive-oil and rape-oil, in the production of light, two lamps, like that just described, were made use of; and, the experiment being made with all possible care, the consumption of olive-oil appeared to be to that of rape-oil, in the production of the same quantity of light, as 129 is to 125.

The experiment being afterwards repeated with olive-oil and very pure linseed-oil, the consumption of olive-oil appeared to be to that of linseed oil as 129 to 120.

The experiment being twice made with olive oil and with a tallow candle; once when the candle, by being often snuffed, was made to burn constantly with the greatest possible brilliancy, and once when it was suffered to burn the whole time with a very dim light, owing to the want of snuffing; the results of these experiments were very remarkable.

When the candle burnt with a clear, bright flame, the consumption of the olive oil was to the consumption of the tallow as 129 is to 101; but when the candle burnt with a dim light, the consumption of the olive-oil was to the consumption of the tallow as 129 is to 229. So that it appeared, from this last experiment, that the tallow, instead of being nearly as productive of light in its combustion as bees wax, as it appeared to be when the candle was kept constantly well snuffed, was now, when the candle was suffered to burn with a dim light, by far less so than oil.

But this is not all; what is still more extraordinary is, that the very same candle, burning with a long wick, and a dim light, actually consumed *more tallow* than when, being properly snuffed, it burnt with a clear, bright flame, and gave near *three times as much light*.

To be enabled to judge of the relative quantities of light actually produced by the candle in the two experiments, it will suffice to know, that in order to counterbalance this light at the field of the *photometer*, it required, in the former experiment, the consumption of 141 parts, but in the latter only the consumption of 64 parts, of olive-oil. But in the former experiment 110,

and

and in the latter 114, parts of tallow were actually found to be consumed. These parts were 8192ths of a Bavarian pound.

From the results of all the foregoing experiments, it appears that the relative expence of the undermentioned inflammable substances, in the production of light, is as follows:

		Equal Parts in Weight.
Bees wax.	A good wax-candle, kept well snuffed, and burning with a clear, bright flame, - - -	100
Tallow.	A good tallow candle, kept well snuffed, and burning with a bright flame, - - - - -	101
	The same tallow-candle, burning very dim for want of snuffing,	229
Olive-oil.	Burnt in an Argand's lamp, - -	110
	The same burnt in a common lamp, with a clear, bright flame, without smoke, - - - - -	129
Rape-oil.	Burnt in the same manner, - - -	125
Linseed-oil.	Likewise burnt in the same manner, - - - - - -	120

With the foregoing table, and the prices current of the therein mentioned articles, the relative prices of light produced by those different materials may very readily be computed.

In the year 1795, Mr J. H. Hassenfratz was employed by the French government to make a series of experiments to determine the most economical method of procuring light from the different combustible substances usually employed for that purpose. The materials of his experiments were, wax, spermaceti, and tallow candles, fish-oil, oil of coleseed, and of poppy seeds. In using these oils both the Argand and common lamps were employed. The wicks of the latter were round, containing thirty-six cotton threads. The tallow and spermaceti candles were mould, six to the pound. The wax candles five to the pound. Mr Hassenfratz used the same method with Count Rumford for determining the comparative intensity of the lights.

Count Rumford, as we have seen, used the Argand lamp as a standard for comparison; but as the intensity of its light varies according to the height of the wick, Mr Hassenfratz preferred a wax-candle, making use of it soon after it was lighted. When two luminous bodies, of different intensities, are put in comparison with each other, the shadows are of two colours. That from the weakest light is blue, and from the strongest, red. When the lights of two different combustible bodies are compared, they are either red or blue in a compound ratio of the colour and intensity. Thus in comparing the shadows from different luminous bodies, they will be red or blue respectively, in the following order:

Light of the sun.
——- of the moon.
——- of Argand lamps.
——- of tallow-candles.
——- of wax ditto.
——- of spermaceti ditto.
——- of common lamps.

That is to say, when a body is illuminated by the sun and by any other luminous substance, the shadow of the former is red, and of the latter, blue. In like manner, the shadow from an Argand lamp is red, when placed by that of a tallow candle, which is blue.

The following table will shew, according to Mr Hassenfratz, the proportional distance that different luminous bodies should be placed at to produce an equally intense shadow from the same object. The second column gives the proportional intensity of each light, which is known to be in proportion to the squares of the distances of luminous bodies giving the same depth of shadow. The third column shews the quantity of combustible matter consumed in the hour by each mode of giving light, which Mr Hassenfratz calculates from the average of many repeated experiments.

		Distance.	Intensity.	Quantity consumed per hour	Quantity equired for equal intensities.
Argand lamps with	Oil of poppy seed	10	10.000	23	23
	— of fishes	10	10 000	23.77	23.77
	— of cole-seed	9.246	8 549	14.15	16.59
Common lamps with	Oil of cole-seed	6.774	4.588	8.81	19.2
	— of fishes	6.524	4.550	9.14	20.06
	— of poppy-seed	5.917	3.501	7 0	20.14
	Spermaceti candle	5.917	3 501	9.23	
	Old tallow candle	5 473	2.995	7.54	25.17
	New ditto	5.473	2 995	8 .3	27.48
	Wax candle	4.275	1 877	9 54	

The relative quantity of combustible matter required to produce *equal* lights at equal distances, may be obtained by a simple rule of proportion from the above data. Thus, if a given intensity of light, expressed by 3.501, has been produced by a consumption of 9.23 of spermaceti in the hour, the same luminous body will produce a light of 10.000, by consuming in the same time a quantity of spermaceti $= \frac{10.000 \times 9.23}{3.501} = 26.37$.— Therefore we may add to the table a fourth column, expressing the quantity of combustible which each body must consume to produce a light of 10.000.

From what has been laid down, it will also appear that the number of lights required to produce a given light, will be as follows: To produce a light equal to 100 Argand lamps, burning poppy-seed oil, it will require

100 Argand lamps with fish-oil
117 Ditto do. with cole seed oil
218 Common lamps with cole-seed oil
219 Ditto do. with fish-oil
285 Ditto do. with poppy seed oil
285 Spermaceti candles
333 Tallow ditto
546 Wax ditto.

Mr Hassenfratz next takes notice of the comparative price of these articles; by which he finds, that in Paris the most expensive light is that produced from wax-candles; and the most *economical*, that from oil of cole-seed, burned in Argand lamps.

The chief difference between the Argand and com-

mon lamp is, that in the latter much of the oil is volatilized without combustion, and hence the unpleasant smell which it produces; whereas in the former, the heat is so great at the top of the wick, that all the oil is decomposed in passing through, the disposition of the wick allowing the free access of air to assist combustion. It should therefore follow, that the Argand lamp consumes less fuel to produce a given light than the common lamp, and this, as we have seen, is the opinion of Count Rumford. Yet (Mr Hassenfratz observes) there are two circumstances that prevent the full effect of the complete combustion in the Argand lamp. The one is, that the glass cylinder absorbs a part of the rays of light as they pass through; the other, that the column of light proceeding from the inner surface of the wick, is, in part, lost, by being obliged to pass through that from the outer surface. Count Rumford allows the first cause of diminution of light, and estimates it at .1854, but not the latter. The author of this memoir, in repeating Count Rumford's experiments, asserts, that when two candles are placed so that the light of the one is obliged to pass through that of the other, the sum of the light so produced is not so strong as when they are placed side by side; for in the first case, a part of the hindmost light is absorbed by the foremost.

LANCASHIRE. In the account which we have given of that county in the *Encyclopædia*, an obliging correspondent has pointed out to us some mistakes. He assures us, that the sea coast, where we understood the atmosphere to be loaded with such exhalations as produce malignant and intermitting fevers, is remarkably healthy; and he speaks from experience, having lived on that coast for forty years. He assures us likewise, that the Duke of Bridgewater's inland navigation was begun soon after, if not before, the year 1736, and that he (the writer), so early as 1764, was one of a party who sailed up the sough or edit a considerable way to see how the coals were worked. The same correspondent has pointed out a few mistakes in our account of

LANCASTER, the capital of the county. "That town (he says) carries on no trade whatever with North America, but a very considerable one with Jamaica and the other West India islands, in vessels of from 100 to 300 tons burthen. It exports to these islands all such British manufactures as they have occasion for, Irish linens, and salted provisions of all kinds, such as Irish beef, pork, butter, &c. It trades also to the Baltic, Portugal, Hamburgh, &c. to a large amount; and some of its ships with their cargoes have of late been worth from L. 60 to L. 80,000 sterling. It has, however, no communication by water with the rivers Mersey, Dee, &c. as we have said; the canal reaching as yet no farther than to near Preston in Lancashire." The communication with these rivers is indeed intended to be completed; but whether the scheme be practicable is, according to our correspondent, very uncertain.

LANTERN (See *Encycl.*). Sir George Staunton informs us, that of the Chinese lanterns, some were such as we have described, viz. composed of thin silk gauze, painted or wrought in needle-work with figures of birds, insects, flowers, or fruit, and stretched on neat frames of wood. Others, however, were very different, being entirely made of horn. These were so thin and transparent, that they were taken at first for glass; a material to which, for this purpose, the horn is preferred by the Chinese, as cheaper, lighter, less liable to accident, and, in case of accident, more easily repaired; many of them were about two feet in the diameter, and in the form of a cylinder, with the ends rounded off, and the edges meeting in the point to which the suspending cords were tied. Each lantern consisted of an uniform piece of horn, the joints, or seams, being rendered invisible by an art found out by the Chinese; among whom, the vast number of such lanterns used in their dwelling houses and temples, as well as on the occasions of their festivals and processions, have led to many trials for improving their construction. The horns generally employed are those of sheep and goats. The usual method of managing them, according to the information obtained upon the spot, is to bend them by immersion in boiling water, after which they are cut open and flattened; they then easily scale, or are separated into two or three thin laminæ or plates. In order that these plates should be made to join, they are exposed to the penetrating effect of steam, by which they are rendered almost perfectly soft. In this state the edges of the pieces to be joined are carefully scraped and slanted off, so as that the pieces overlapping each other shall not together exceed the thickness of the plate in any other part. By applying the edges, thus prepared, immediately to each other, and pressing them with pincers, they intimately adhere, and incorporating, form one substance, similar in every respect to the other parts; and thus uniform pieces of horn may be prepared to almost any extent. It is a contrivance little known elsewhere, however simple the process appears to be; and perhaps some minute precautions are omitted in the general description, which may be essential to its complete success.

Such lanterns as these would be very proper for military store houses; and Rochon of *the National Institute* was employed, since the commencement of the present war, to make them, if he could, for the marine storehouses of France. While he was thus engaged, however, it occurred to him, that he might supply the pressing wants of the navy without horn, merely by filling up the interstices of wire-cloth with fine transparent glue. In carrying this thought into execution, he at first tinned the iron wires of the sieve cloth he made use of; but afterwards found it more convenient, in every respect, to give it a slight coating of oil paint to preserve it from rust. The glue he made use of was afforded by boiling the clippings of parchment with the air-bladders and membranes of sea fish; materials which he used, not from any notion that they were preferable to isinglass, but because they were the cheapest he could procure. He added the juice of garlic and cyder to his composition, in such proportions as he found to communicate great tenacity, and somewhat more of transparence than it would have possessed without them. Into this transparent and very pure glue or size he plunged his wire cloth, which came out with its interstices filled with the compound. It is requisite that the size should possess a determinate heat and consistence, concerning which experience alone must guide the operator.

When this prepared wire cloth is fixed in the lantern, it must be defended from moisture by a coating of pure drying linseed oil; but even in this state it is not fit to be exposed to the weather. The ease with which these lanterns are repaired in case of accident, by a

slight

flight coating of glue, is pointed out as a great advantage by the inventor; who likewise informs us, that they were used in the expedition to Ireland as signal lanterns, though contrary to his wishes.

LAPIS FUNGIFER, a species of earth found near Rome, Naples, and Florence, of which the following account is taken from the *New Transactions of the Royal Academy of Sciences at Stockholm* for the year 1797: Near Naples the lapis fungifer is found in the chalk-hills like a white stalactites, intermixed with a great many fine roots of shrubs; and near Florence there is a species of it, consisting of hardened turf, which is dug up near volcanoes. The author made experiments with a piece procured from Italy, and found that 100 parts contain from 45 to 46 siliceous earth, 23 argillaceous earth, 7 calcareous earth, and 20 calx of iron, with some white magnesia and vegetable alkali. It is well known, that when this friable species of stone is preserved in cellars and moistened with water, it produces abundance of eatable mushrooms, which in Italy are highly esteemed and brought to the first tables. Hence the origin of its name.

LARDIZABALA, a new genus of plants belonging to the *diœcia hexandria* of Linnæus. It is a native of Chili, and is thus described in Perouse's Voyage, from drawings sent to France by La Martiniere. The leaves are alternate, on footstalks inflated at their base. Each leaf is bi-ternate, that is to say, it is divided into three leaflets, each of which is again subdivided into three oval sharp-pointed folioles, which, when young, are entire, but afterwards become obscurely lobed. The flowers, disposed in simple and pendent clusters, grow towards the top of the stem and of the branches in the axillæ of the leaves. The plant is diœcius. At the base of each cluster of blossoms are two small, rounded, oval, floral leaves.

MALE FLOWER.—*Calyx* formed of six expanding leaves, oblong oval, and obtuse, of which the three outermost are the largest. *Corolla* composed of six sharp lanceolated petals, opposite to, and shorter than, the leaves of the calyx. A cylinder rises from the centre of the flower of the length of the petals, terminated by six oblong bilocular anthers, which open from below.

FEMALE FLOWER.—*Calyx*, similar to that of the male flower, but larger. *Corolla* inserted beneath the pistil, composed of six petals, rarely entire, but generally bifid or trifid at their summit: shorter than the leaves of the calyx. *Stamina* six, having the same insertion as the corolla; filaments distinct, broad, very short, surrounding the pistil; *anthers*, six, upright, oblong, acuminated, barren. *Seed bud*, cells, from three to six, oblong, gibbous on the outside, of nearly the length of the corolla; styles none; stigmata, sitting, oblong, permanent. *Berries*, equal in number to the cells, oblong, acuminated (divided into six cells, containing several angular seeds. *Flora Peruviana*).

The general character of the lardizabala evidently places this new genus among the family of the *menispermæ*, to which it is related by its climbing stalk, its bunches of diœcious flowers, by its six petals, stamina, and leaves of its calyx, by its pistil, composed of from three to six cells, which contain as many seeds. It differs from the known genera of this order only in its fruit, which, instead of being monospermous, contains several seeds. This character, which requires the introduction of a new section into the *menispermæ*, strengthens the relation of this family to the next order of the *anonæ*. In fact, the greater part of the genera of the anonæ, as they have in the same flower several fruits, with numerous seeds, differ in this particular from all the genera of the menispermæ; and by placing between them the lardizabala, we establish a natural transition. In order to confirm these resemblances, it only remains to examine the inside of the fruit, and particularly the structure of the seeds. Those of the menispermæ are reniform, at least on the inside, inclosed in a hinged pericarpium, and containing in their upper part a very small dicotyledonous embryo. The characters that we have given of the lardizabala render probable a similar structure in its seeds.

LARMIER, in architecture, a flat square member of the cornice below the cimasium, and jets out farthest; being so called from its use, which is to disperse the water, and cause it to fall at a distance from the wall, drop by drop, or, as it were, by tears; *larme* in French signifying a tear.

LATUS PRIMARIUM, a right line drawn through the vertex of the section of a cone, within the same, and parallel to the base.

Latus Rectum. See *Conic Section*, Encycl.

Latus Transversum of the hyperbola, is the right line between the vertices of the two opposite sections, or that part of their common axis lying between the two opposite cones.

LAVA. In addition to the observations of Sir William Hamilton, Bergmann, Formes, and Dalmieu, on the composition of different lavas, which have been given in the *Encyclopædia*, we cannot refuse ourselves the pleasure of noticing, in this place, those of Sir James Hall. From a number of well-devised experiments, Sir James thinks himself warranted to conclude, that lava and whinstone are intrinsically the same substance; and that their apparent differences arise wholly from the circumstances under which they have passed from a liquid to a solid state. The lavas, it is well known, have been cooled rapidly in the open air, and the whins (according to Dr Hutton's theory, which Sir James seems willing to adopt) slowly in the bowels of the earth.

Though we are far from adopting that theory in all its parts, to which we think insuperable objections may be made (see EARTH, *Encycl.* n° 120), we admit, that the experiments of Sir James Hall go far to establish the identity of lava and whinstone. These experiments were made upon seven different species of whin and six lavas, of which four were broken from the rents of Etna and Vesuvius by Sir James himself. I of the original whinstones was reduced, by fusion and subsequent rapid cooling, to a state of perfect glass. This glass, being again placed in the furnace, was subjected to a second fusion. The heat, being then reduced to a temperature generally about 28° of Wedgewood, was maintained stationary for some hours; when the crucible was either immediately removed, or allowed to cool with the furnace. The consequence was, that in every case the substance had lost the character of glass, and by crystallization had assumed in all respects that of an original whinstone. It must be owned, that in most cases the new production did not exactly resemble the particular original from which it was formed,

Lava, Lavoisier.

ed, but some other original of the same class; owing to accidental varieties in the mode of refrigeration, and to chemical changes which unavoidably took place during the process. In the case, however, of the rock of Edinburgh castle, and of that of the basaltic columns of Staffa, the artificial substances bear a complete resemblance to their originals, both in colour and texture.

The lavas were now treated in the same way, and were each, by fusion and rapid cooling, reduced, as the whinstones had been, to glass. This glass, when fused again and cooled slowly, yielded the same kind of crystallized, stony, or earthy masses, completely resembling an original whin or lava.

Although the internal structure of lava was thus accounted for, yet Sir James was embarrassed with the state of its external surface; which, though cooled in contact with the open air, is seldom or never vitreous, holding an intermediate station between glass and stone; but this difficulty was removed by a circumstance which took place in the course of these experiments. It was found, that a small piece of glass of any of the lavas, or of several of the whins, being introduced into a muffle, the temperature of which was at any point between the 20th and the 22d degree of Wedgewood's scale, the glass became quite soft in the space of one minute; but, being allowed to remain till the end of a second minute, it was found to have become hard throughout in consequence of a rapid crystallization, to have lost its character of glass, and to have become by 12 or 14 degrees more infusible, being unaffected by any heat under 30, though the glass had been fusible at 18° or at 16°. This accounted for the scoria on the surface of lavas; for the substance even at the surface, being in contact with the flowing stream, and surrounded with heated air, could not cool with excessive rapidity; and the experiment shews, that should any part of the mass, in descending heat, employ more than one or two minutes in cooling from 22 to 20, it would infallibly lose its vitreous character.

Independently of any allusion to system or to general theory, Sir James Hall flatters himself that these experiments may be of some importance, by simplifying the history of volcanoes; and, above all, by superseding some very extraordinary, and, he conceives, unphilosophical opinions advanced with regard to volcanic heat, which has been stated as possessing very little intensity, and as acting by some occult and inconceivable influence, or with the help of some invisible agent, so as to produce liquidity without fusion. These suppositions, which have been maintained seriously by some of the most celebrated naturalists in Europe, have originated from the difficulty of accounting for the stony character of lavas when compared with that of glass, which they assume in consequence of fusion in our furnaces. But now he hopes we may be relieved from the necessity of such violent efforts of imagination, since the phenomena have been fully accounted for by the simple, though unnoticed, principle of refrigeration, and have been repeated again and again with ease and certainty in a small chamber furnace.

LAVOISIER (Antoine Laurent), was born in Paris on the 26th of August 1743. His father, who directed his education, was opulent, and spared no cost for his improvement. The youth shewed a decided taste for the physical sciences. In 1764, government having proposed an extraordinary premium for the best and cheapest mode of lighting the streets of a large city, Lavoisier obtained the gold medal; and his memoir, full of nice investigation, was printed by the Academy. Into that body he was received on the 13th May 1768, in spite of a formidable opposition; and to its service he ever after devoted his labours, and became one of its most useful associates and coadjutors.

His attention was successively occupied with every branch of physical and mathematical science. The pretended conversion of water into earth, the analysis of gypsum in the neighbourhood of Paris, the crystallization of salts, the effects produced by the *grande de loupe* of the garden of the Infanta, the project of bringing water from l'Yvette to Paris, the congelation of water, and the phenomena of thunder and the aurora borealis—all occupied his attention.

Journeys, undertaken in concert with Guettard into every district of France, enabled him to procure numberless materials towards a description of the lithological and mineralogical empire; these he arranged into a kind of chart, which wanted little of being completed. They served also as a foundation for a more laborious work of his on the revolutions of the globe, and the formation of *Couches de la Terre*; a work of which two beautiful sketches are to be seen in the Memoirs of the French Academy for 1772 and 1787. All the fortune and all the time of Lavoisier were devoted to the culture of the sciences; nor did he seem to have a preponderating inclination for any one in particular, until an event, such as seldom occurs in the annals of the human mind, decided his choice, and attached him thenceforth exclusively to chemistry—a pursuit which has since rendered his name immortal.

The important discovery of gases was just announced to the philosophical world. Black, Priestley, Scheele, Cavendish, and Macbride, had opened to physiologists a sort of new creation; they had commenced a new era in the annals of genius, which was to become equally memorable with those of the compass, printing, electricity, &c.

It was about the year 1770 that Lavoisier, struck with the importance and grandeur of this discovery, turned his attention to this inexhaustible fountain of truths, and instantly perceived, by a kind of instinct, the glorious career which lay before him, and the influence which this new science would necessarily have over the whole train of physical researches. Of those who had preceded him, the most indefatigable experimenter was Priestley; but facts the most brilliant remained frequently unproductive in his hands; on every occasion he was ready to frame some crude hypothesis, which as hastily he abandoned. Lavoisier was imbued with the true spirit of inductive philosophy; his observations, eminently precise and luminous, always pointed to general views. In 1774, he published his chemical opuscules, which contained a very neat history of all that had been done with respect to gases, and concluded with the author's capital experiments, by which it was proved, that metals, in calcination, derive their augmentation of weight from the absorption of air. Soon afterward, he shewed, in opposition to Priestley, that nitrous acid is composed of air; a remark, of which the importance appeared in the sequel. His ingenuity as a chemist was now so well known, that in 1776 Turgot employed

ed him to inspect the manufacture of gun-powder. He introduced some valuable improvements, and, suppressing the odious visits in quest of the materials of saltpetre, he yet quintupled its produce. The gun powder would now carry 120 toises, when formerly it would not reach 90. This superiority was indeed acknowledged in the last war.

It had been alleged, that by frequent distillation water is converted into earth. This question Lavoisier resolved in 1778, having shewn that the earthy sediment was owing to the continual erosion of the internal surface of the retort. In that same year he made a more interesting discovery; namely, that the respirable portion of the atmosphere is a constituent principle of all acids, and which he therefore denominated *oxygen*; a most important fact, and the first great step towards the new chemistry, which the composition of water, ascertained in 1783, triumphantly completed.

Lavoisier possessed decisive advantages over his contemporaries; he studied a geometrical accuracy of investigation; and his wealth enabled him to make experiments on a large scale, and to use instruments of the most perfect construction. He was able to hold in his house, twice every week, assemblies, to which he invited every literary character that was most celebrated in geometrical, physical, and chemical, studies; in these instructive *conversaziones*, discussions, not unlike such as preceded the first establishment of academies, regularly took place. Here the opinions of the most eminent literati in Europe were canvassed; passages the most striking and novel, out of foreign writers, were recited and animadverted on; and theories were compared with experiments. Here learned men of all nations found easy admission; Priestley, Fontana, Blagden, Ingenhousz, Landriani, Jacquin, Watt, Bolton, and other illustrious physiologists and chemists of England, Germany, and Italy, found themselves mixed in the same company with La Place, La Grange, Borda, Cousin, Meunier, Vandermonde, Monge, Morveau, and Berthollet. Happy hours passed in these learned interviews, wherein no subject was left uninvestigated that could possibly contribute to the progress of the sciences, and the amelioration and happiness of man. One of the greatest benefits resulting from these assemblages, and the influence of which was soon afterwards felt in the academy itself, and consequently in all the physical and chemical works that have been published for the last twenty years in France, was the agreement established in the methods of reasoning between the natural philosophers and the geometricians. The precision, the severity of style, the philosophical method of the latter, was insensibly transfused into the minds of the former; the philosophers became disciplined in the tactics of the geometricians, and were gradually moulded into their resemblance.

It was in the assemblage of these talents that Lavoisier embellished and improved his own. When any new result from some important experiment presented itself, a result which threatened to influence the whole theory of the science, or which contradicted theories till then adopted, he repeated it before this select society. Many times successively he invited the severest objections of his critical friends; and it was not till after he had surmounted their objections, to the conviction and entire persuasion of the society; it was not till after he had removed from it all mystery and obscurity, that he ventured to announce to the world any discovery of his own.

At length he combined his philosophical views into a consistent body, which he published in 1789, under the title of *Elements of Chemistry*; a book which is a most beautiful model of scientific composition, clear, logical, and elegant. It would be foreign to our purpose to attempt an exposition of the principles, or to expatiate on the merits, of this celebrated system; which, within the space of a very few years, has been almost universally adopted; and which, if not the genuine interpretation of nature, approaches as near to it as the present state of knowledge will permit. See CHEMISTRY in this *Supplement*.

The last, but not the least useful, of Lavoisier's philosophical researches, on the Perspiration of Animals, was read to the Academy on the 4th May 1791, and of which part was published in the volume for 1790. He found, by some delicate experiments, made in conjunction with Segnin, that a man in 24 hours perspires 45 ounces; that he consumes 33 ounces of vital air; that he discharges from the lungs 8 cubic feet of carbonic acid gas, of which one-third is carbon and two-thirds are oxygen; that the weight of water discharged from the lungs amounts to 23 ounces, of which 3 are hydrogen and 20 oxygen, exclusive of 6 ounces of water already formed, lost in pulmonary perspiration. These discoveries were directed to the improvement of medicine.

We have mentioned the assistance which Lavoisier received while he was digesting his new system of chemistry; but we must add, that to him pertains exclusively the honour of a founder. His own genius was his sole conductor, and the talents of his associates were chiefly useful in illustrating discoveries he himself had made; he first traced the plan of the revolution he had been a long time conceiving; and his colleagues had only to pursue and execute his ideas.

In the twenty volumes of the Academy of Sciences, from 1772 to 1793, are 40 memoirs of Lavoisier, replete with all the grand phenomena of the science; the doctrine of combustion, general and particular; the nature and analysis of atmospherical air; the formation and fixation of elastic fluids; the properties of the matter of heat; the composition of acids; the augmentation of the ponderosity of burnt bodies; the decomposition and recomposition of water; the dissolution of metals; vegetation, fermentation, and animalization. For more than 15 years consecutive, Lavoisier pursued, with unshaken constancy, the route he had marked out for himself, without making a single false step, or suffering his ardour to be damped by the numerous and increasing obstacles which constantly beset him.

Many were the services rendered by Lavoisier, in a public and private capacity, to manufactures, to the sciences, and to artists. He was treasurer to the Academy after Buffon and Tillet, and introduced economy and order into the accounts. He was also a member of the Board of Consultation, and took an active share in whatever was going forwards. When the new system of measures was agitated, and it was proposed to determine a degree of the meridian, he made accurate experiments on the expansion of metals, and constructed a metalline thermometer. By the National Conven-

tion he was consulted on the means of improving the manufacture of assignats, and of increasing the difficulties of forging them.

Like a good citizen, Lavoifier turned his thoughts to political economy. Between the years 1778 and 1785, he allotted 240 *arpents* in the Vendômois to experimental agriculture, and increased the usual produce by one-half. In 1791, he was invited by the Constituent Assembly to digest a plan for simplifying the collection of the taxes. This gave occasion to an excellent report, afterwards printed with the title of *Territorial Riches of France*. At this time, also, he was appointed commissioner of the national treasury, in which he effected some beneficial reforms.

During the horrors of the Robespierrean dictatorship, Lavoisier told La Lande that he foresaw he should be stripped of his property, but that he would work for his bread. The profession of apothecary would have suited him the best. But his doom was already fixed. On the 8th of May 1794, confounded with 28 farmers general, he suffered on the scaffold, merely because he was rich!

Lavoifier was tall, and of a graceful, sprightly appearance. He was mild, sociable, obliging, and extremely active; and in his manners he was unaffectedly plain and simple. Many young men, not blessed with the gifts of fortune, but incited by their genius to woo the sciences, have confessed their obligations to him for pecuniary aid; many, also, were the unfortunate whom he relieved in silence, and without the ostentation of virtue. In the communes of the department of the *Loir* and *Char*, where he possessed considerable estates, he would frequently visit the cottages of indigence and distress; and long will his memory be cherished there. But his reputation, influence, virtues, and wealth, gave him a great preponderance, which unfortunately provoked the jealousy of a crew of homicides, who made a sport of sacrificing the lives of the best of men to a sanguinary idol.

This great and good man married, in 1771, Marie-Anni-Pierette Paulze, daughter of a farmer-general; a woman whose wit and accomplishments constituted the charm of his life; who assisted him in his labours, and even engraved the figures of his last work.

LEAD. See that article (*Encycl.*), and CHEMISTRY-*Index* in this *Supplement*. It is well known, that lead generally contains a portion of silver, and sometimes of gold; and that there are occasions, particularly in assaying, when it is of importance to have it freed from these metals. For accomplishing these purposes different processes have been proposed; but the following by Pet. Jac. Hjelm, as it is the least expensive, promises to be the most useful.

LITHARGE (see *Encycl.*) was the substance on which this chemist made his experiments, and his principal object was to free it from all mixture of silver. This was accomplished in the following manner: He placed a crucible, in which half a pound of litharge found good room, and which was fitted with a close cover, in a wind-furnace filled with dead coals. He then put into the crucible a mixture of four ounces of potash and the same quantity of powder of flint. When the whole was well melted by strengthening the draught, and making the coals glow, he took off the cover, and laid hold of the crucible with a pair of tongs, in order to take it out, and to suffer this very fusible glass to cover the inside of the crucible, to secure it from the glass of the lead which he meant to melt in it. The superfluous glass was poured out; the crucible again placed on its foot, and half a pound of litharge thrown into it with a shovel. The cover was placed upon it while the litharge was melting; and when it was thoroughly glowing and fluid, charcoal dust was sifted into the uncovered crucible through a sieve, so that the surface of the litharge was completely covered with it. This immediately produced an effervescence, and the rising of bubbles, by means of the separation of the air occasioned by the reduction of the lead. During this process, the cover was put on, and a few coals thrown into the furnace; when these were burnt, every thing in the crucible was quiet, and the melted mass was poured into a warm conical mould. The crucible was then again filled with half a pound of the same kind of litharge, and put into the furnace, and charcoal dust was several times sifted over the melted surface, till it was well covered before the mass was thrown out, a sufficient space being every time left for the effervescence. The first mass had, in the mean time, become cool, and, on examination, contained four ounces of lead at the bottom, and litharge at the top. When this litharge was reduced with potashes and wine-stone, the lead thence obtained, which weighed 2½ ounces, was found to contain less than one-half grain of silver in the pound. In the second mass there was found somewhat more than six ounces of lead, which contained all the silver that had been before mixed with the litharge, because in the lead which had been reduced from the litharge in the above manner, there were no perceptible traces of silver. This lead was then melted over a slow fire, and cast into bars, which were rolled smooth, and formed into masses of a known weight, to be used for assaying gold and silver, and for other purposes of the same kind. All these meltings were made in one crucible, which, according to every appearance, remained unhurt. If the same experiments were made with red lead, the like result would infallibly follow.

With the same view of obtaining lead free from silver, he melted, in the like manner, half a pound of white lead, which produced half an ounce of lead. When the litharge standing over it was revived, the lead obtained was still found to contain too much silver. He therefore precipitated another half pound of white lead by charcoal powder, after the lead that fell from it had been separated; and then it produced, by reviving, a mass of lead without any mixture of silver.

LEDYARD (——.——), the celebrated, though unfortunate, traveller, was a native of North America, but of what province we have not learned. We are equally ignorant of the year of his birth, and the rank of his parents; but have no reason to think that they were opulent. From his early youth he displayed a strong propensity to visit unknown and savage countries; and to gratify that propensity, he lived for several years with the American Indians, whose manners and habits he seemed in some degree to have acquired. Afterwards he sailed round the world with Captain Cook in the humble station of a corporal of marines; and on his return, he determined to traverse the vast continent of America, from the Pacific to the Atlantic Ocean.

This design being frustrated by his not obtaining a

passage

Ledyard.

passage to Nootka Sound, he determined to travel over land to Kamschatka. With this view he went over to Ostend, with only ten guineas in his pocket, and proceeded by the way of Denmark and the Sound to the capital of Sweden, and endeavoured to cross the Gulph of Bothnia on the ice; but finding, when he came to the middle, that the water was not frozen, he walked round the gulph to Petersburgh. Here he found himself without stockings or shoes; but procured relief from the Portuguese ambassador, and obtained leave to proceed with a detachment of stores to Yakutz. He made this journey of six thousand miles, and there met Mr Billengs, an Englishman, whom he had known on board Captain Cook's ship. From thence he went to Oczakow, on the coast of the Kamschatka Sea; but being too late to embark that year, returned to Yakutz to winter. Here he was, on some suspicion, seized, conveyed on a sledge through Northern Tartary, and left on the frontiers of the Polish dominions. In the midst of poverty, rags, and disease, he however reached Koningsburg, where he found friends that enabled him to reach England.

On his arrival in London, he waited on Sir Joseph Banks, on whose credit he had, in his distress, received at different times 25 guineas. Sir Joseph communicated to him the views of the African Association, and pointed out the route in which they wished Africa to be explored. On his engaging at once in the enterprise, Sir Joseph asked him when he would be able to set out. "To-morrow morning," replied Ledyard, without hesitation. At this interview the president of the Royal Society declares, that he was struck with the figure of the man, the breadth of his chest, the openness of his countenance, and the rolling of his eye. Though scarcely exceeding the middle size, his figure indicated great strength and activity. Despising the accidental distinctions of society, he seemed to regard no man as his superior; but his manners, though coarse, were not disagreeable. His uncultivated genius was original and comprehensive. From the native energy of his mind, he was adventurous, curious, and unappalled by dangers; while the strength of his judgment united caution with energy. The track pointed out to him was from Cairo to Senaar, and thence westward in the latitude and supposed direction of the Niger.

He was not ignorant, that the task assigned him was arduous and big with danger; but instead of shrinking from it, he said, on the day of his departure, "I am accustomed to hardships; I have known both hunger and nakedness to the utmost extremity of human suffering; I have known what it is to have food given me as charity to a madman; and I have at times been obliged to shelter myself under the miseries of that character to avoid a heavier calamity. My distresses have been greater than I ever owned, or ever will own to any man. Such evils are terrible to bear, but they never yet had power to turn me from my purpose. If I live, I will faithfully perform, in its utmost extent, my engagement to the Society: and if I perish in the attempt, my honour will be safe; for death cancels all bonds."

After receiving his instructions and letters of recommendation, this intrepid traveller sailed from London on the 30th of June 1788; and in 36 days arrived at Alexandria. Proceeding to Cairo, where he arrived August the 17th, he visited the slave markets, and conversed with the travelling merchants of the caravans. These sources of information, generally neglected by travellers, enabled him to obtain, at a very small expence, more correct information concerning the African nations and their trade, the position of places, the nature of the country, the manner of travelling, &c. than could have been easily obtained by any other method. He thus learned, that the Arabs of the desert have an invincible attachment to liberty, though it is singular that they have no word to express liberty in their language. The Mahomedans of Africa are a trading, superstitious, and warlike set of vagabonds. He saw near 200 black slaves exposed to sale, who had been brought from the interior parts of Africa; their appearance savage, but not like [illegible] head ornaments, and their hair [illegible] of great length. Another parcel, which had come from Darfoor, were mostly women; and the beads, and some other ornaments which they wore, were Venetian. They were well formed, quite black, had the true Guinea face, and curled hair. Mr Ledyard was informed, that the king of Senaar was a merchant, and concerned in the caravans; that 20,000 negro slaves are imported into Egypt annually. Among these Senaar slaves, he saw them of a bright olive colour, but their heads uncommonly formed, the forehead the narrowest, longest, and most protuberant he ever saw.

The Senaar caravan is the most rich; that of Darfoor is not equally so, though it trades with almost the same commodities. Besides slaves, these are gum, elephants teeth, camels, and ostrich feathers; for which are received in exchange trinkets, soap, antimony, red linen, razors, scissars, mirrors, and beads. Wangara, to which the caravans also trade, was represented to Mr Ledyard as a kingdom producing much gold; but the king seems to intermeddle with commerce as well as the potentate of Senaar; for in order to deceive strangers, and prevent them from guessing at the extent of his riches, he was reported to vary continually the gold used in barter, which it is his province to regulate, and of which he issues at one time a great quantity, and at others little or none. A caravan goes from Cairo to Fezzan, which they call a journey of fifty days; and as the caravans travel about 20 miles a day, the distance must be about 1000 miles; from Fezzan to Tombuctoo is 1800 miles; from Cairo to Senaar about 600 miles.

Such was the information which Mr Ledyard derived from the merchants of the caravans in Egypt; but when he was about to verify it by his own observations, and had announced to the Association that his next dispatch would be dated from Senaar, he was seized with a bilious complaint, which frustrated the skill of the most eminent physicians, and put a period to his travels and his life at Cairo. It is needless to say how much his death was regretted, or how well he was qualified for the arduous enterprise in which he had engaged. The person who, with [illegible], could penetrate the frozen regions of Tartary, [illegible] among their churlish inhabitants, and ingratiate himself with the ferocious Moors of Egypt, could hardly have failed to obtain a kind reception from the gentle and hospitable Negro, had no untoward circumstances intervened. At Senaar, indeed, his risk would have been great; and Mr Bruce was decidedly of opinion, that a man so poorly attended as Mr Ledyard, could never have made his escape from that treacherous and ferocious people.

The

The observations of this accurate observer on the female character, though they have been repeatedly quoted in other works, are well intitled to a place here; and with them we shall conclude this sketch of his life: "I have always (says he) remarked, that women in all countries are civil and obliging, tender and humane; that they are ever inclined to be gay and cheerful, timorous and modest; and that they do not hesitate, like man, to perform a generous action. Not haughty, not arrogant, not supercilious; they are full of courtesy, and fond of society; more liable, in general, to err than man; but in general also more virtuous, and performing more good actions than he. To a woman, whether civilized or savage, I never addressed myself, in the language of decency and friendship, without receiving a decent and friendly answer. With man it has often been otherwise. In wandering over the barren plains of inhospitable Denmark, through honest Sweden, and frozen Lapland, rude and churlish Finland, unprincipled Russia, and the wide spread regions of the wandering Tartar; if hungry, dry, cold, wet, or sick, the women have ever been friendly to me, and uniformly so. And to add to this virtue (so worthy the appellation of benevolence), these actions have been performed in so free and kind a manner, that if I was dry, I drank the sweetest draught; and if hungry, I eat the coarsest morsel with a double relish." For a fuller account of *Ledyard*, see *The Transactions of the African Association*, or *A View of the Late Discoveries in Africa*.

Hyperbolic LEGS, are the ends of a curve line that partakes of the nature of the hyperbola, or having asymptots.

LEMINGTON Priors, is a village two miles east of the town of Warwick, famous for its mineral waters. One salt spring, which rises near the church yard, has been long known, as well as another which rises in the bed of the river; but the most remarkable spring was discovered in the year 1790. The waters of both springs have been analyzed with great accuracy by William Lambe, M. A. late Fellow of St John's college, Cambridge, who has given us the following synoptical table of the substances contained in them:

Gaseous Fluids contained in a Wine gallon in Cubic Inches.

	WATER OF THE NEW SPRING.	WATER OF THE OLD SPRING.
Hepatic gas	*Too small to be measured.*	*Too small to be measured.*
Azotic gas	3.5	3
Carbonic acid gas	.5	—

Solid contents of a Wine gallon in Grains.

	WATER OF THE NEW SPRING.	WATER OF THE OLD SPRING.
Carbonat of iron	.75	
Oxyds of iron and manganese	—	*Too small to be weighed.*
Oxygenated muriat of iron and manganese	*Unknown, but very small.*	*Unknown, but very small.*
Sulphur	*Unknown, but very small.*	—
Muriat of magnesia	11.5	58
Muriat of soda	430	330
Sulphat of soda	152	62
Sulphat of lime	112	146

In the course of his experiments, for which we must refer to the original memoir, in Transactions of the Manchester Society, Mr Lambe thinks he discovered the origin of the *muriatic acid*. He found a coincidence, very unexpected, between the hepatised solution of iron and the oxygenated muriat of iron. "I had almost concluded (says he), from the resemblance between the properties of this salt and the phenomena of the water, that the water contains this very salt. Now, I conclude, that they contain a matter, be it what it may, produced by the action of hepatic gas on iron. But they are the very same facts which form the basis, upon which each separate inference is built. Does it not follow, then, as a necessary consequence, that the hepatised solution itself contains a muriat of iron highly oxygenated, and that therefore *in this process muriatic acid is generated?* This conclusion seemed authorised by reason, and experiment has confirmed it."

LEMNISCATE, the name of a curve in the form of the figure of 8.

LEMON-juice, is an article of such harmless luxury, and in some cases of such real utility, that many of our readers will be pleased to know a simple method by which they may obtain it in great purity. In the article Chemistry (*Suppl.*), nº 476, we have shewn from Scheele and Dizé, how to obtain the citric acid perfectly pure, and in the form of crystals; but here we mean nothing more than to shew how it may be completely separated from that slimy substance with which it is always mixed in the lemon, without allowing it time to spoil or to acquire any disagreeable taste during the separation. This we are enabled to do by M. Brugnatelli, who, in the 2d volume of the *Annali di Chimia*, informs us, that he expressed in the common manner the juice of perfectly ripe lemons, and strained it through a piece of linen. In half an hour he strained it again, to free it from a little slimy matter which had settled at the bottom of the vessel. He then added to the juice a certain quantity of the strongest spirit of wine, and preserved the mixture for some days in a well corked bottle. During that time there was a considerable deposit, which to all appearance was of a slimy nature, and which he separated by filtering paper. If the fluid was too thick to pass through the filter, he diluted it again with spirit of wine. After this operation, the deposit remained on the paper, which was entirely covered with it; and he obtained, in the vessel placed below, the purest acid of lemons combined with spirit of wine.

If it be required to obtain the acid perfectly pure, nothing is necessary but to separate from it the spirit of wine, which can be best effected by evaporation. The acid of the lemons assumes, after it has been freed from the spirit of wine and the moisture combined with it, a yellowish colour, and becomes so strong, that by its taste it might be considered as a mineral acid.

It is not necessary to evaporate the spirit of wine in a close vessel, if the experiment is made only on a small scale; nor is there any danger that in open vessels any of the acid will be lost, as it is too fixed to be volatilised by the same degree of heat at which spirit of wine evaporates. This acid has peculiar properties, which deserve farther examination.

LENSES (see Lens and Dioptrics, *Encycl.*), are either blown or ground.

Blown Lenses are used only in the single microscope;

Lenses, Leo.

and the usual method of making them has been to draw out a fine thread of the soft white glass called *crystal*, and to convert the extremity of this into a spherule by melting it at the flame of a candle. But this glass contains lead, which is disposed to become opake by partial reduction, unless the management be very carefully attended to. We are informed, however, by Mr Nicholson, that the hard glass used for windows seldom fails to afford excellent spherules. This glass is of a clear bright green colour when seen edgewise. A thin piece was cut from the edge of a pane of glass less than one-tenth of an inch broad. This was held perpendicularly by the upper end, and the flame of a candle was directed upon it by the blow-pipe at the distance of about an inch from the lower end. The glass became soft, and the lower piece descended by its own weight to the distance of about two feet, where it remained suspended by a thin thread of glass about one five-hundredth of an inch in diameter. A part of this thread was applied endwise to the lower blue part of the flame of the candle without the use of the blow-pipe. The extremity immediately became white-hot, and formed a globule. The glass was then gradually and regularly thrust towards the flame, but never into it, until the globule was sufficiently large. A number of these were made; and being afterwards examined, by viewing their focal images with a deep magnifier, proved very bright, perfect, and round. This, as the ingenious author observes, may prove an acceptable piece of information to those eminent men (and there are many such), whose narrow circumstances, or remote situations, are obliged to have recourse to their own skill and ingenuity for experimental implements.

Ground Lenses, are such as are ground or rubbed into the desired shape, and then polished. Different shapes have been proposed for lenses; but in the article Optics, n° 252 (*Encycl.*), it has been shewn that, after all, the spherical is the most practically useful. By many of the methods of grinding, however, the artificer, with his utmost care, can only produce an approximation to a truly spherical figure; and, indeed, gentlemen have, for the most part, nothing to depend on for the sphericity of the lenses of their telescopes, but the care and integrity of the workmen. In the 41st volume of the Transactions of the Royal Society of London, a machine is described by Mr Samuel Jenkins, which, as it is contrived to turn a sphere at one and the same time on two axes, cutting each other at right angles, will produce the segment of a true sphere merely by turning round the wheels, and that without any care or skill in the workmen. The following description of this machine will enable our readers fully to comprehend its construction, and the mode of using it: A is a globe covered with cement, in which are fixed the pieces of glass to be ground. This globe is fastened to the axis, and turns with the wheel B. C is the brass cup which polishes the glass: this is fastened to the axis, and turns with the wheel D. The motion of the cup C, therefore, is at right angles with the motion of the globe A; whence it follows demonstrably, that the pieces of glass ground by this double motion must be formed into the segments of spheres.

Plate XII

LEO X. is a pontiff to whom learning, and art, and science, are so deeply indebted, that not to give a sketch of his life and character, in a Work of this kind, would be an unpardonable omission. A character of him is indeed given in the *Encyclopædia*; but it is so far from the truth, that it is difficult to conceive the prejudices under which he must have laboured by whom such a libel was drawn up.*

Leo, whose name, before his elevation to the pontificate, was *Giovanni de Medici*, was the second son of Lorenzo de Medici, justly styled the Magnificent. In the life of that great man published in this *Supplement*, the reader will see by what means, and for what purpose, he got Giovanni raised to the dignity of cardinal at so early a period of life; and in the elegant work of Roscoe, to which we there refer, he will find such instructions of Lorenzo to the cardinal as must have made a deep impression on his youthful mind.

Speaking of his promotion, Lorenzo says, "The first thing that I would suggest to you, is, that you ought to be grateful to God, and continually to recollect that it is not through your merits, your prudence, or your solicitude, that this event has taken place, but through his favour, which you can repay only by a *pious*, *chaste*, and *exemplary life*; and that your obligations to the performance of these duties are so much the greater, as in your *early years* you have given some *reasonable expectation* that your riper age may produce such fruits. It would indeed be highly disgraceful, and as contrary to your duty as to my *hopes*, if at a time when others display a greater share of reason, and adopt a better mode of life, you should forget the *precepts of your youth*, and forsake the path in which you have *hitherto trodden*."—"I well know (continues Lorenzo), that as you are now to reside at Rome, that sink of all iniquity, the difficulty of conducting yourself by these admonitions will be increased. The influence of example is itself prevalent; but you will probably meet with those, who will particularly endeavour to corrupt and incite you to vice; because, as you yourself may perceive, your early attainment of so great a dignity is not observed without envy, and those who could not prevent your receiving that honour, will secretly endeavour to diminish it, by inducing you to forfeit the good estimation of the public."—"You are not unacquainted with the great importance of the character which you have to sustain; for you well know, that all the Christian world would prosper if the cardinals were what they ought to be; because in such a case there would always be a good pope, upon which the tranquillity of Christendom so materially depends."

As this was a confidential letter from Lorenzo to his son, the first of these extracts furnishes very sufficient evidence, that Giovanni had been at least a well behaved boy, diligent in his studies, and regular in his conduct; and without supposing him remarkably religious, the admonitions of such a father, aided by his own ambition and love of letters, would surely guard him against such gross licentiousness as that of which he is accused in the *Encyclopædia*. How much he revered his father, is apparent from the letter which he wrote to his brother immediately after Lorenzo's death. "What a father (says he) have we lost! How indulgent to his children! Wonder not, then, that I grieve, that I lament, that I find no rest. Yet, my brother, I have some consolation in reflecting that I have thee, whom I shall always regard in the place of a father." Surely this is not the language of a gross sensualist, or of one who could soon

forget

forget the salutary admonitions of such a parent as Lorenzo de Medici. But it is needless to infer the decency of his character by such reasonings as these. The story published in the *Encyclopædia*, of the manner in which the Cardinal de Medici obtained the tiara, cannot possibly be true. The reader, who shall turn to the article POPE in that Work, will find that the conclave, when fitted up for an election, is so large a place, that we may safely affirm, that had the cardinal's ulcer discharged matter so fetid as to *poison all the cells*, the assertion of the physicians would have been verified, and that in the then state of the healing art, the new pope could not have survived a month. Let it be remembered, too, that Leo, at his accession, was not 30, but 37 years of age, and that he had long ruled in Florence with sovereign sway by the same means which had upheld the authority of his father. The follies of youth, therefore, had he ever been remarkable for such follies, must have been over with him; and in such a state as Florence he could not have maintained the authority of Lorenzo, without exhibiting not only Lorenzo's liberality, but likewise his decency of manners.

The next charge brought against Leo in the *Encyclopædia* is, that he published general indulgences throughout Europe; and this is so expressed as to lead the ill informed reader to suppose, either that no such indulgences had ever been published by any of his predecessors, or that there was something peculiarly scandalous in Leo's mode of publishing them. Both suppositions, however, are erroneous. The historian of the council of Trent, who certainly was not partial to the court of Rome, or to the dispensing power of the pope, has shewn, that the practice of raising money by the publication of indulgences, had prevailed ever since the year 1100; that many former popes had raised money in this manner for purposes much less laudable than those which Leo had in his eye; and that the real cause of Luther's attack upon Leo's indulgences was, that they were preached through Saxony by the Dominican friars; whereas the preaching of former indulgences had been committed to the hermits of St Augustine, the order to which Luther himself belonged!

Leo is likewise accused in the *Encyclopædia* of being a professed infidel, and of having called Christianity "a fable very profitable for him and his predecessors." But of the truth of this accusation there seems not to be the shadow of evidence. Leo had too much sense to utter expressions of this kind, even had he been an unbeliever in his heart; for he could not possibly expect that his indulgences and pardons would be purchased, had he declared in such strong terms that they were of no value. Father Paul indeed says, that he was not a deep divine, or so pious as some of his predecessors; but he affirms, that he *adorned the papacy* with many admirable qualities; that he was learned, affable, liberal, *good*; that he delighted in healing differences, and that his equal had not, for many years, filled the chair of St Peter. Surely this is not the character of a profane infidel!

Leo has been charged with raising his own family to grandeur at the expence of justice; and of dealing treacherously, in order to effect this purpose, both with the emperor and with the French king. But the charge is either false or greatly exaggerated. He lost no opportunity indeed of aggrandizing his relations, well knowing, that in order to secure to them any lasting benefit, it was necessary that they should be powerful enough to defend themselves, after his death, from the rapacious aims of succeeding pontiffs; but, in prosecuting this plan, he was so far from acting tyrannically or injuriously to others, that during his pontificate, the papal dominions enjoyed a degree of tranquillity superior to any other Italian state. During the contests that took place between the emperor and the French king, so far from acting treacherously, he distinguished himself by his moderation, his vigilance, and his political address; on which account he is justly celebrated by an eminent historian of our own *, as "the only prince of the age who observed the motions of the two contending monarchs with a prudent attention, or who discovered a proper solicitude for the public safety."

* Dr Robertson.

We trust that no zealous Protestant will think we have employed our time ill, in vindicating the character of this splendid pontiff; for good learning, and, of course, true religion, are more indebted to Leo X. than to any other individual of the age in which he lived, his father Lorenzo alone excepted.

Leo Minor, the *Little Lion*, a constellation of the northern hemisphere, and one of the new ones that were formed out of what were left by the ancients, under the name of *Stellæ Informes*, or unformed stars. See ASTRONOMY, n° 406, *Encycl.*

LESLIE (Charles), was a man so eminent for his learning, his talents, and his piety, that a fuller account of him than that which is given in the *Encyclopædia* must be acceptable to our Christian readers. He was the second son of Dr John Leslie bishop of Clogher in Ireland, who was descended from an ancient family in the north of Scotland, and being an admirable scholar, rose to the dignity of bishop of Orkney in his own country, whence he was translated, in 1633, to Raphoe in Ireland, and afterwards, in 1661, to the see of Clogher.

Our author was born in Ireland, but in what year we have not learned. A ludicrous story goes indeed of his having been begotten in prison, and of his father having said that he hoped he would, in consequence become the greatest scourge of the covenanters that Great Britain or Ireland had ever seen. This story, with all its circumstances as told to us, can hardly be true; but we think it could not have been fabricated, had not Charles Leslie been born within a year of Cromwell's conquest of Ireland, when the good bishop, having sustained a siege in his castle of Raphoe against that arch rebel, was some time kept in close confinement.

We are equally ignorant of the school where he was educated as of the year of his birth; but we know that he had his academical education in Trinity College, Dublin, where he took the degree of master of arts. In the year 1671, he lost his father, when he came over to England, and, entering himself in the temple, studied law for some years, but afterwards relinquished it for the study of divinity. In 1680, he was admitted into holy orders; and, in 1687, was made chancellor of Connor.

About this period he rendered himself particularly obnoxious to the Popish party in Ireland, by his zealous opposition to them, which was thus called forth. Roger Boyle, bishop of Clogher, dying in 1687, Patrick Tyrrel was made titular Popish bishop, and had the revenues of the see assigned him by king James. He set

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 up

 up a convent of friars in Monaghan: and, fixing his habitation there, held a public visitation of his clergy with great solemnity; when, some subtle logicians attending him, he was so insolent as to challenge the Protestant clergy to a public disputation. Leslie undertook the task, and performed it to the satisfaction of the Protestants; though it happened, as it generally does at such contests, that both sides claimed the victory. He afterwards held another public disputation with two celebrated Popish divines, in the church of Tynan, in the diocese of Armagh, before a very numerous assembly of persons of both religions; the issue of which was, that Mr John Stewart, a Popish gentleman, solemnly renounced the errors of the church of Rome.

As the Papists had got possession of an Episcopal see, they engrossed other offices too; and a Popish high-sheriff was appointed for the county of Monaghan. This proceeding alarmed the gentlemen in that county; who, depending much on Leslie's knowledge as a justice of peace, repaired to him, then confined, by the gout, to his house. He told them, that it would be as illegal in them to permit the sheriff to act as it would be in him to attempt it. But they insisting that he should appear himself on the bench at the next quarter sessions, and all promising to stand by him, he was carried thither with much difficulty and in great pain. When the sheriff appeared, and was taking his place, he was asked whether he was legally qualified? to which he answered pertly, "That he was of the king's own religion, and it was his majesty's will that he should be sheriff." Leslie replied, "That they were not inquiring into his majesty's religion, but whether he (the pretended sheriff) had qualified himself according to law, for acting as a proper officer; that the law was the king's will, and nothing else to be deemed such; that his subjects had no other way of knowing his will, but as it is revealed to them in his laws; and it must always be thought to continue so, till the contrary is notified to them in the same authentic manner." Upon this, the bench unanimously agreed to commit the pretended sheriff for his intrusion and arrogant contempt of the court. Leslie also committed some officers of that tumultuary army which the Lord Tyrconnel raised for robbing the country.

In this spirited conduct Leslie acted like a sound divine and an upright magistrate; but though he thought himself authorised to resist the illegal mandates of his sovereign, like many other great and good men, he distinguished between active and passive obedience; and felt not himself at liberty to transfer his allegiance from that sovereign to another. Refusing therefore to take the oaths to king William and queen Mary, he was deprived of all his preferments; and in 1689 he removed with his family to England, where he published the following works, besides those already noticed in the *Encyclopedia*: 1. Answer to Archbishop King's State of the Protestants in Ireland. 2. Cassandra, concerning the new Associations, &c. 1703, 4to. 3. Rehearsals; at first a weekly paper, published afterwards twice a-week in a half-sheet, by way of dialogue on the affairs of the times; begun in 1704, and continued for six or seven years. 4. The Wolf stripped of his Shepherd's Clothing, in Answer to Moderation a Virtue, 1704, 4to. The pamphlet it answers was written by James Owen. 5. The Bishop of Sarum's [Burnet's] proper Defence, from a Speech said to be spoken by him against occasional conformity, 1704, 4to. 6. The new Association of those called Moderate Churchmen, &c. occasioned by a pamphlet, intitled, The Danger of Priestcraft, 1705, 4to. 7 The new Association, part 2d, 1705, 4to. 8. The Principles of Dissenters concerning Toleration and occasional Conformity, 1705, 4to. 9. A Warning for the Church of England, 1706, 4to. Some have doubted whether these two pieces were his. 10. The good old Cause, or Lying in Truth; being a second Defence of the Bishop of Sarum from a second Speech, &c. 1710. For this a warrant was issued out against Leslie. 11. A Letter to the Bishop of Sarum, in Answer to his Sermon after the Queen's Death, in Defence of the Revolution, 1715. 12. Salt for the Leech. 13. The Anatomy of a Jacobite. 14. Gallienus redivivus. 15. Delenda Carthago. 16 A Letter to Mr William Molyneux, on his Case of Ireland's being bound by the English Acts of Parliament. 17. A Letter to Julian Johnson. 18. Several Tracts against Dr Higden and Mr Hoadly. 19. A Discourse, shewing who they are that are now qualified to administer Baptism. 20. The History of Sin and Heresy, &c. 1698, 8vo. 21. The Truth of Christianity demonstrated, in a Dialogue between a Christian and a Deist, 1711, 8vo.—Against the Papists: 22. Of private Judgment and Authority in Matters of Faith. 23. The Case stated between the Church of Rome and the Church of England, &c 1713. 24. The true notion of the Catholic Church, in Answer to the Bishop of Meaux's Letter to Mr Nelson, &c.

Besides these, he published the four following tracts: 25. A Sermon preached in Chester, against Marriages in different Communions, 1702, 8vo. This sermon occasioned Mr Dodwell's discourse upon the same subject. 26. A Dissertation concerning the Use and Authority of Ecclesiastical History. 27. The Case of the Regal and the Pontificate. 28. A Supplement, in Answer to a Book, intitled, The regal Supremacy in Ecclesiastical Affairs asserted, &c. These two last pieces were occasioned by the dispute about the rights of convocation, between Wake, &c. on one side, and Atterbury and his friends, among whom was Leslie, on the other.

It is said by the authors of the Biographical Dictionary, that, in consequence of a publication of his, intitled, "The hereditary right of the crown of England asserted," he was under the necessity of leaving the kingdom; and that he repaired to the Pretender at Bar le duc, where he was allowed to officiate, in a private chapel, after the rites of the church of England; and where he endeavoured, though in vain, to convert the Pretender to the Protestant religion.

That he repaired to *Bar le duc*, and endeavoured to convert to the church of England him whom he considered as the rightful sovereign of England, is indeed true; but we have reason to believe that this was not in consequence of his being obliged to leave the kingdom. There is, in the first place, some grounds to believe, that "The hereditary right of the crown of England asserted" was not written by him; and there is still in existence undoubted evidence, that, in consequence of his great fame as a polemic, he was sent to *Bar le duc* for the express purpose of endeavouring to convert the son of James II. by some gentlemen of fortune in England, who wished to see that prince on the throne of

... he had the honour, 16 or 17 years ago, to be known to the grand-daughter of one of those gentlemen—a lady of the strictest veracity; and from her he received many anecdotes of Leslie and his associates, which, as he did not then foresee that he should have the present occasion for them, he has suffered to slip from his memory. That lady is still alive, and we have reason to believe is in possession of many letters by Leslie, written in confidence to her grandfather, both from *Bar le duc* and from St Germains; and by the account which she gave of these letters, Leslie appears to have considered his prince as a weak and incorrigible bigot, though, in every thing but religion, an amiable and accomplished man. This may have been his genuine character; for we all know that it was the character of his father; but it is not of him that we are writing.

Mr Leslie having remained abroad from the year 1709 till 1721, returned that year to England, resolving, whatever the consequences might be, to die in his own country. Some of his friends acquainting lord Sunderland with his purposes, implored his protection for the good old man, which his lordship readily and generously promised. Mr Leslie had no sooner arrived in London, than a member of the house of commons officiously waited on lord Sunderland with the news, but met with such a reception from his lordship as the malice of his errand deserved. Our author then went over to Ireland, where he died April 13. 1722. at his own house at Glaslough in the county of Monaghan.

His character may be summed up in a few words. Consummate learning, attended by the lowest humility, the strictest piety without the least tincture of moroseness, a conversation to the last degree lively and spirited, yet to the last degree innocent, made him the delight of mankind, and leaves what Dr Hickes says of him unquestionable, that he made more converts to a sound faith and holy life than any other man of our times.

A charge, however, has been lately brought against him of such a nature, as, if well founded, must detract not only from his literary fame, but also from his integrity. "The short and easy Method with the Deists" is unquestionably his most valuable, and apparently his most original work; yet this tract is published in French among the works of the Abbé St Real, who died in 1692; and therefore it has been said, that unless it was published in English prior to that period, Charles Leslie must be considered as a shameless plagiary.

The English work was certainly not published prior to the death of Abbé St Real; for the first edition bears date July 17th 1697; and yet many reasons conspire to convince us, that our countryman was no plagiary. There is indeed a striking similarity between the English and the French works; but this is no complete proof that the one was copied from the other. The article PHILOLOGY in the *Encyclopædia Britannica*, of which Dr Doig is the author, was published the very same week with Dr Vincent's dissertation on the Greek verb. It was therefore impossible that either of these learned men, who were till then strangers to each others names, could have stolen aught from the other; and yet Dr Vincent's derivation of the Greek verb bears as striking a resemblance to Dr Doig's as the Abbé St Real's work does to Charles Leslie's. In the article MIRACLE (*Encycl.*), the credibility of the gospel miracles is established by an argument, which the author certainly borrowed from no man, and which the late principal Campbell considered as original; yet within half a year of the publication of that article, the credibility of the gospel miracles was treated in the very same manner by F. SAYERS, M. D. though there is in his dissertation complete internal evidence that he had not seen the article in the *Encyclopædia*. Not many months ago, the author of this sketch reviewed, in one of the journals, the work of a friend, which was at the same time reviewed in another journal, that at this moment he has never seen. Yet he has been told by a friend, who is much versant in that kind of reading, and knows nothing of his concern with either review, that the book in question must, in both journals, have been reviewed by the same hand; because in both the same character is given of it in almost the very same words!

After these instances of apparent plagiarism, which we know to be *only* apparent, has any man a right to say that Charles Leslie and the Abbé St Real might not have have treated their subject in the way that they have done, without either borrowing from the other? The coincidence of arrangement and reasoning in the two works is indeed very surprising; but it is by no means so surprising as the coincidence of etymological deductions which appears in the works of the Doctors Doig and Vincent. The divines reason from the acknowledged laws of human thought; the reasonings of the grammarians, with all due deference to their superior learning, we cannot help considering as sometimes fanciful.

But this is not all that we have to urge on the subject. If there be plagiarism in the case, and the identity of titles looks very like it, it is infinitely more probable that the editor of St Real's works stole from Leslie, than that Leslie stole from St Real, unless it can be proved that the works of the Abbé, and this work in particular, were published before the year 1697. At that period, the English language was very little read or understood on the continent; whilst in Britain the French language was, by *scholars*, as generally understood as at present. Hence it is, that so many Frenchmen, and indeed foreigners of different nations, thought themselves safe in pilfering science from the British philosophers*; whilst there is not, that we know, one well authenticated instance of a British philosopher appropriating to himself the discoveries of a foreigner. If, then, such men as LEIBNITZ, John BERNOULLI, and DES CARTES, trusting to the improbability of detection, condescended to pilfer the discoveries of HOOKE, NEWTON, and HARRIOT, is it improbable that the editor of the works of St Real would claim to his friend a celebrated tract, of which he knew the real author to be obnoxious to the government of his own country, and therefore not likely to have powerful friends to maintain his right?

But farther, Burnet, bishop of Sarum, was an excellent scholar, and well read, as every one knows, in the works of foreign divines. Is it conceivable, that this prelate, when smarting under the lash of Leslie, would have let slip so good an opportunity of covering with disgrace his most formidable antagonist, had he known that antagonist to be guilty of plagiarism from the writings of the Abbé St Real? Let it be granted, however,

Leslie.

* See *Quantity* (Encyc.), *Astronomy*, *Dynamics*, *Impulsion*, and *Harriot*, in this Suppl.

Leslie || Licenser.

however, that Burnet was a stranger to these writings and to this plagiarism; it can hardly be supposed that *Le Clerc* was a stranger to them likewise. Yet this author, when, for reasons best known to himself, he chose (1706) to depreciate the argument of *the short method*, and to traduce its author as ignorant of ancient history, and as having brought forward his four marks for no other purpose than to put the deceitful traditions of Popery on the same footing with the most authentic doctrines of the gospel, does not so much as insinuate that he borrowed these marks from a Popish abbé, though such a charge, could he have established it, would have served his purpose more than all his rude railings and invective. But there was no room for such a charge. In the second volume of the works of St Real, published in 1757, there is indeed a tract entitled *Methode Courte et Aisée pour combattre les Deistes*; and there can be little doubt but that the publisher wished it to be considered as the work of his countryman. Unfortunately, however, for his design, a catalogue of the Abbé's works is given in the first volume; and in that catalogue the *Methode Courte et Aisée* is not mentioned.

We have dwelt thus long on *The Short and Easy Method with the Deists*, because it is one of the ablest works that ever was written in proof of the Divine origin of the Jewish and Christian Scriptures; a work of which the merit is acknowledged by Lord Bolingbroke, and which, as has been observed elsewhere (see Theology, n° 16. *Encycl.*) Dr Conyers Middleton confesses to be unanswerable. If by men of science we be thought to have spent our time well in vindicating the rights of our illustrious philosophers Hooke and Newton, to discoveries which have been unjustly claimed by the philosophers of Germany and France; we will not surely by the friends of Christianity be thought to have employed our time ill in vindicating Leslie's claim to this decisive argument in support of our holy religion.

LEVER, the first of the mechanical powers, for the properties of which see Mechanics; and for a demonstration of its fundamental property, see Steel yard, both in the *Encyclopædia*.

LICENSER of Books (see Liberty *of the Press*, *Encycl.*), has been an officer in almost every civilized nation, till the end of the last century that the office was abolished in Great Britain. Professor Beckmann, with his usual industry*, has proved that such an office was established not only in the Roman Empire, but even in the republic, and in the free states of ancient Greece. At Athens, the works of Protagoras were prohibited; and all the copies of them which could be collected were burnt by the public crier. At Rome, the writings of Numa, which had been found in his grave, were, by order of the senate, condemned to the fire, because they were contrary to the religion which he had introduced. As the populace at Rome were, in times of public calamity, more addicted to superstition than seemed proper to the government, an order was issued, that all superstitious and astrological books should be delivered into the hands of the prætor. This order was often repeated: and the emperor Augustus caused more than twenty thousand of these books to be burnt at one time. Under the same emperor the satirical works of Labienus were condemned to the fire, which was the first instance of this nature; and it is related as something singular, that, a few years after, the writings of the person who had been the cause of the order for that purpose shared the like fate, and were also publicly burnt. When Cremutius Cordus, in his history, called C. Cassius the last of the Romans, the senate, in order to flatter Tiberius, caused the book to be burnt; but a number of copies were saved by being concealed. Antiochus Epiphanes caused the books of the Jews to be burnt; and in the first centuries of our æra the books of the Christians were treated with equal severity, of which Arnobius bitterly complains. We are told by Eusebius, that Dioclesian caused the sacred Scriptures to be burnt. After the spreading of the Christian religion the clergy exercised, against books that were either unfavourable or disagreeable to them, the same severity which they had censured in the heathens as foolish and prejudicial to their own cause.

* *History of Inventions*, vol 3.

Licenser, Lichen.

Soon after the invention of printing, laws began to be made for subjecting books to examination; a regulation proposed even by Plato; and which has been wished for by many since. Our author gives a great deal of curious information on this important subject, which our limits do not permit us to repeat; but it is apparent from his work, that the liberty of the press is but a modern privilege; and that it has not been enjoyed completely in any country but this happy island.

LICHEN (see *Encycl.*), is a genus of plants, of which the most valuable species seems to be the Lichen Rocella, or *Argol*. As that species has not been noticed in the article referred to, the following account of it from Professor Beckmann will be acceptable to many of our readers:

It is found in abundance in some of the islands near the African coast, particularly in the Canaries, and in several of the islands in the Archipelago. It grows upright, partly in single, partly in double stems, which are about two inches in height. When it is old, these stems are crowned with a button sometimes round, and sometimes of a flat form, which Tournefort, very properly, compares to the excrescences on the arms of the sepia. Its colour is sometimes a light, and sometimes a dark grey. Of this moss, with lime, urine, and alkaline salts, is formed a dark red paste, which in commerce has the same name, and which is much used in dyeing. That well-known substance called lacmus is also made of it.

Theophrastus, Dioscorides, and their transcriber Pliny, give the name of *Phycos thalassion*, or *pontion*, to this plant, which, notwithstanding its name, is not a sea weed but a moss; as it grew on the rocks of different islands, and particularly on those of Crete or Candia. It had, in their time, been long used for dyeing wool, and the colour it gave when fresh was so beautiful, that it excelled the ancient purple, which was not red, as many suppose, but violet. Pliny tells us, that with this moss dyers gave the ground or first tint to those cloths which they intended to dye with the costly purple. When it was first employed as a dye by the moderns, is not so certain, though the Professor has proved, we think completely, that it must have been at least as early as the beginning of the 14th century.

"Among the oldest and principal Florentine families (says he), is that known under the name of the Oricellarii

Lichen. Oricellarii or Rucellarii, Rofcellai or Rucellai, feveral of whom have diftinguifhed themfelves as ftatefmen and men of letters. This family are defcended from a German nobleman, named Ferro or Frederigo, who lived in the beginning of the twelfth century. One of his defcendants, in the year 1300, carried on a great trade in the Levant, by which he acquired confiderable riches, and returning at length to Florence, with his fortune, firft made known in Europe the art of dyeing with argol. It is faid, that a little before his return from the Levant, happening to make water on a rock covered with this mofs, he obferved, that the plant, which was there called *refpio*, or *refpo*, and in Spain *orciglia*, acquired by the urine a purple, or, as others fay, a red colour. He therefore tried feveral experiments; and when he had brought to perfection the art of dyeing wool with this plant, he made it known at Florence, where he alone practifed it for a confiderable time, to the great benefit of the ftate. From this ufeful invention, the family received the name of Oricellarii, from which, at laft, was formed Rucellai." The Profeffor, however, does not believe that this Florentine difcovered the dye by means of the above-mentioned accident, but that he learned the art in the Levant, and on his return taught it to his countrymen.

"Our dyers do not purchafe raw argol, but a pafte made of it, which the French call *orfeille en pâte*. The preparation of it was for a long time kept a fecret by the Florentines. The perfon who, as far as I know, made it firft known was Rofetti; who, as he himfelf tells us, carried on the trade of dyer at Florence. Some information was afterwards publifhed concerning it by Imperati * and Micheli the botanift †. In later times this art has been much practifed in France, England, and Holland. Many druggifts, inftead of keeping this pafte in a moift ftate with urine, as they ought, fuffer it to dry, in order to fave a little dirty work. It then has the appearance of a dark violet-coloured earth, with here and there fome white fpots in it.

* Lib. xxvii c. 9.
† *Nova Plantarum genera Florentiae*, 1729.

"The Dutch (continues our author), who have found out better methods than other nations of manufacturing many commodities, fo as to render them cheaper, and thereby to hurt the trade of their neighbours, are the inventors alfo of lacmus, a preparation of argol, called *orfeille en pierre*, which has greatly leffened the ufe of that *en pâte*, as it is more eafily tranfported and preferved, and fitter for ufe; and as it is befides, if not cheaper, at leaft not dearer. This art confifts, undoubtedly, in mixing with that commodity fome lefs valuable fubftance, which either improves or does not much impair its quality, and which, at the fame time, increafes its weight (A). Thus do they pound cinnabar and fmalt finer than other nations, and yet fell both thefe articles cheaper. Thus do they fift cochineal, and fell it cheaper than what is unfifted.

"It was for a long time believed, that the Dutch prepared their lacmus from thofe linen rags which in the fouth of France are dipped in the juice of the *croton tinctorium*; but at prefent, it is almoft certainly known, that *orfeille en pâte* is the principal ingredient in *orfeille en pierre* that is in lacmus; and for this curious information we are indebted to Ferber. But whence arifes the fmell of the lacmus, which appears fo like that of the Florentine iris?" Some of the latter may, perhaps, be mixed with it; for our author thinks, that he has obferved in it fmall indiffoluble particles, which may have been bits of the roots. The addition of this fubftance can be of no ufe to improve the dye; but it may increafe the weight, and give the lack more body; and perhaps it may be employed to render imperceptible fome unpleafant fmell, for which purpofe the roots of that plant are ufed on many other occafions.

Light. LIGHT, it has been obferved in the article CHEMISTRY, n° 319. (*Suppl.*), confifts of rays differently flexible. This was eftablifhed by fome well devifed experiments made by Henry Brougham, Efq; of which it may be proper to give an account here.

In the firft experiment, he darkened his chamber in the ufual way, and let a beam of the fun's light into it through the hole of a metal plate fixed in the fhutter of the window, [illegible]th of an inch in diameter. At the hole within the room he placed a prifm of glafs, of which the refracting angle was 45 degrees, and which was everywhere covered with black paper, except a fmall part on each fide; and through this part the light was refracted fo as to form a diftinct fpectrum on a chart at fix feet diftance from the window. In the rays, at two feet from the prifm, he placed a black unpolifhed pin, of which the diameter was [illegible]th of an inch, parallel to the chart, and in a vertical pofition. The fhadow of the pin was found in the fpectrum; and this fhadow had a confiderable penumbra, which was broadeft and moft diftinct in the violet part, narroweft and moft confufed in the red, and of an intermediate thicknefs and diftinctnefs in the intermediate colours. The penumbra was bounded by curvilinear fides, convex towards the axis to which they approached as their afymptote, fo as to be neareft to it in the place of the leaft refrangible rays. By moving the prifm on its axis, and caufing the colours to afcend and defcend on any bodies that were ufed inftead of the pin, the red, wherever they fell, made the leaft, and the violet the greateft fhadow.

In the next experiment, a fcreen was fubftituted in the place of the pin; and this fcreen had a large hole, on which was a brafs plate, pierced with a fmall hole [illegible]d of an inch in diameter. While an affiftant moved the prifm flowly on its axis, the author obferved the round image made by the different rays paffing through the hole to the chart; that made by the red was greateft, that of the violet leaft, and that of each intermediate rays was of an intermediate fize. When the fharp blade of a knife was held at the back of the hole, "fo as to produce the fringes mentioned by Grimaldo and Newton, thefe fringes in the red were broadeft and moft moved inwards to the fhadow, and moft dilated when the knife was moved over the hole; and the hole itfelf on the chart was more dilated during the motion when illuminated by the red than when illuminated by any other of the rays, and leaft of all when illuminated by the violet."

From thefe two experiments, the author infers "that the rays of the fun's light differ in degree of flexibility, and

(A) As dry lacmus is much cheaper than moift, it may be readily fuppofed that it is adulterated with fand and other fubftances. *Valentini Hiftoria fimplicium*. Francf. ad Moen. 1716. fol. p. 152.

Limbers ‖ Lotus.

and that those which are least *refrangible* are *most inflexible*." From other experiments, he concludes, that the *most inflexible* rays are also *most deflexible*. In the sequel of his paper, he ascertains the proportion which the angle of *inflection* bears to that of *deflection* at equal incidences, and the proportion which the different *flexibilities* of the different rays bear to one another. We shall give an account of some other experiments made by him, and of the inferences drawn from them, under the word REFLEXITY, to which a reference has already been made.

LIMBERS, in artillery, a sort of advanced train, joined to the carriage of a cannon on a march. It is composed of two shafts, wide enough to receive a horse between them, called the *fillet horse*: these shafts are joined by two bars of wood, and a bolt of iron at one end, and mounted on a pair of rather small wheels. Upon the axle-tree rises a strong iron spike, which is put into a hole in the hinder part of the train of the gun-carriage, to draw it by. But when a gun is in action, the limbers are taken off, and run out behind it.

LIMIT OF A PLANET, has been sometimes used for its greatest heliocentric latitude.

LIMITED Problem, denotes a problem that has but one solution, or some determinate number of solutions; as to describe a circle through three given points that do not lie in a right line, which is limited to one solution only; to divide a parallelogram into two equal parts by a line parallel to one side, which admits of two solutions, according as the line is parallel to the length or breadth of the parallelogram; or to divide a triangle in any ratio by a line parallel to one side, which is limited to three solutions, as the line may be parallel to any of the three sides.

LOCAL PROBLEM, is one that is capable of an infinite number of different solutions; because the point, which is to solve the problem, may be indifferently taken within a certain extent; as suppose any where in such a line, within such a plane figure, &c. which is called a *geometrical Locus*.

A local problem is *simple*, when the point sought is in a right line; *plane*, when the point sought is in the circumference of a circle; *solid*, when it is in the circumference of a conic section; or *sursolid*, when the point is in the perimeter of a line of a higher kind.

LOCI, the plural of

LOCUS, a line by which a local or indeterminate problem is solved; or a line of which any point may equally solve an indeterminate problem. See ALGEBRA, *Encycl.*

LOGISTIC CURVE, the same with *LOGARITHMIC Curve*, for which see *Encycl.*

LOGISTICS, or *LOGISTICAL Arithmetic*, a name sometimes employed for the arithmetic of sexagesimal fractions, used in astronomical computations.

The same term has been used for the rules of computations in algebra, and in other species of arithmetic: witness the logistics of Vieta and other writers.

Shakerly, in his *Tabulæ Britannicæ*, has a table of logarithms adapted to sexagesimal fractions, and which he calls Logistical Logarithms; and the expeditious arithmetic, obtained by means of them, he calls Logistical Arithmetic.

LIBYAN LOTUS has been described (*Encycl.*) under the title RHAMNUS; but the following additional particulars from Mr Park will be acceptable to our botanical readers:

Lotus, Lowang.

The lotus is very common in all the countries which our author visited, and he had an opportunity to make a drawing of a branch in flower, of which an engraving is published in his travels, that with his permission we have copied (see Plate XXX.). The lotus produces fruit which the negroes call *tomberongs*. These are small farinaceous berries, of a yellow colour and delicious taste. They are much esteemed by the natives, who convert them into a sort of bread, by exposing them for some days to the sun, and afterwards pounding them gently in a wooden mortar, until the farinaceous part of the berry is separated from the stone. This meal is then mixed with a little water, and formed into cakes; which, when dried in the sun, resemble in colour and flavour the sweetest gingerbread. The stones are afterwards put into a vessel of water, and shaken about so as to separate the meal which may still adhere to them; this communicates a sweet and agreeable taste to the water, and with the addition of a little pounded millet, forms a pleasant gruel called *fondi*, which is the common breakfast in many parts of Ludamar, during the months of February and March. The fruit is collected by spreading a cloth upon the ground, and beating the branches with a stick. Our author thinks there can be little doubt of this being the lotus mentioned by Pliny, as the food of the Lybian Lotophagi. An army may very well have been fed with the bread made of the meal of the fruit, as is said by Pliny to have been done in Lybia; and as the taste of the bread is sweet and agreeable, it is not likely that the soldiers would complain of it.

LOWANG, a Chinese island of some extent in the neighbourhood of the CHUSAN-Isles, which see in this *Supplement*. Some of the gentlemen belonging to the British embassy went ashore on Lowang, which they described as naked both of trees and of cattle. They examined particularly a small level plain recovered from the sea, which was kept out by an embankment of earth, at least thirty feet thick. The quantity of ground gained by it seemed scarcely to be worth the labour that it must have cost. The plain was indeed cultivated with the utmost care, and laid out chiefly in rice-plats, supplied with water collected from the adjacent hills into little channels, through which it was conveyed to every part of those plantations. It was manured, instead of the dung of animals, with matters more offensive to the human senses, and which are not very generally applied to the purposes of agriculture in England. Earthen vessels were sunk into the ground for the reception of such manure; and for containing liquids of an analogous nature, in which the grain was steeped previously to its being sown; an operation which is supposed to hasten the growth of the future plant, as well as to prevent any injury from insects in its tender state.

The party fell in with a peasant who, though struck with their appearance, was not so feared by it as to shun them. He was dressed in loose garments of blue cotton, a straw hat upon his head fastened by a string under his chin, and half boots upon his legs. He seemed to enter into the spirit of curiosity, naturally animating travellers, and readily led them towards an adjoining village.

village. Passing by a small farm house, they were invited into it by the tenant, who, together with his son, observed them with astonished eyes. The house was built of wood, the uprights of the natural form of the timber. No ceiling concealed the inside of the roof, which was put together strongly, and covered with the straw of rice. The floor was of earth beaten hard, and the partitions between the rooms consisted of mats hanging from the beams. Two spinning wheels for cotton were seen in the outer room; but the seats for the spinners were empty. They had probably been filled by females, who retired on the approach of strangers; while they remained, none of that sex appeared. Round the house were planted clusters of bamboo, and of that species of palm, of which each leaf resembles the form of a fan; and, used as such, becomes an article of merchandize.

LOXODROMIC Curve, or *Spiral*, is the same as the rhumb line, or path of a ship sailing always on the same course in an oblique direction, or making always the same angle with every meridian. It is a species of logarithmic spiral, described on the surface of the sphere, having the meridians for its radii.

LOXODROMICS, the art or method of oblique sailing, by the loxodromic or rhumb line.

LUCIOLE, a name given in the *Annales de Chimie* to the *Lampyris Italica* (See Lampyris, *Encycl.*). According to Dr Carradori, the light of the luciole does not depend on the influence of any external cause, but merely on the will of those insects. While they fly about at freedom, their shining is very regular; but when they are once in our power, they shine very irregularly, or do not shine at all. When they are molested, they emit a frequent light, which appears to be a mark of their resentment. When placed on their backs, they shine almost without interruption, making continual efforts to turn themselves from that position. In the daytime it is necessary to torment them in order to make them shine; and thence it follows, that the day to them is the season of repose. The luciole emit light at pleasure from every point of their bellies, which proves that they can move all the parts of their viscera independently of each other. They can also render their phosphorescence more or less vivid, and continue it as long as they please.

A slight compression deprives the luciole of their power of ceasing to shine. The author is inclined to believe, that the movement by which they conceal their light is executed by drawing back their phosphoric substance into a particular membrane or tunic. He supposes also, that the sparkling consists in a trembling or oscillation of the phosphoric mass. He is of opinion, that there is no emanation of a phosphoric substance, and that the whole phenomenon takes place in the interior part of the luminous viscera. When the shining is at its greatest degree of height, it is so strong that a person may by it easily distinguish the hours on the smallest watch, and the letters of any type whatever.

The phosphoric part of the luciole does not extend farther than to the extreme rings of the belly. It is there inclosed in a covering composed of two portions of membranes, one of which forms the upper, and the other the lower, part of the belly, and which are joined together. Behind this receptacle is placed the phosphorus, which resembles a paste, having the smell of garlic, and very little taste. The phosphoric matter issues from a sort of bag on the slightest pressure; when squeezed out, this matter loses its splendour in a few hours, and is converted into a white dry substance. A portion of the phosphoric belly put into oil, shone only with a feeble light, and was soon extinguished. In water, a like portion shone with the same vivacity as in the air, and for a much longer time. The author thence concludes, that the phosphorescence of the luciole is not the effect of slow inflammation, nor of the fixation of azotic gas, as the oil in which they shine does not contain a single air-bubble: besides, the phosphorus of these insects shines in a barometrical vacuum. The observation made by Foster, that the luciole sed a more vivid light in oxygen gas than in atmospheric air, does not, according to Carradori, depend upon a combustion more animated by the inspiration of this gas, but on the animals feeling themselves, while in that gas, in a better condition. "Whence, then, arises (says the author) the phosphoric light of the luciole? I am of opinion (adds he), that the light is peculiar and innate in these insects, as several other productions are peculiar to other animals. As some animals have the faculty of accumulating the electric fluid, and of keeping it condensed in particular organs, to diffuse it afterwards at pleasure, there may be other animals endowed with the faculty of keeping in a condensed state the fluid which constitutes light. It is possible, that by a peculiar organization they may have the power of extracting the light which enters into the composition of their food, and of transmitting it to the reservoir destined for that purpose, which they have in their abdomen. It is not even impossible that they may have the power to extract from the atmospheric air the luminous fluid, as other animals have the power of extracting from the same air, by a chemical process, the fluid of heat."

Carradori discovered, that the phosphorescence of the luciole is a property independent of the life of these animals, and that it is chiefly owing to the soft state of the phosphoric substance. Its light is suspended by drying, and it is again revived by softening it in water; but only after a certain time of desiccation. Reaumur, Beccaria, and Spallanzani, observed the same thing in regard to the *pholades* and the *medusa*.

By plunging the luciole alternately into lukewarm and cold water, they shine with vivacity in the former, but their light becomes extinct in the latter; which, according to the author, depends on the alternate agreeable and disagreeable sensation which they experience. In warm water their light disappears gradually. Dr Carradori tried on the luciole and their phosphorus the action of different saline and spirituous liquors, in which they exhibited the same appearances as other phosphoric animals. These last experiments prove that the phosphoric matter of the luciole is only soluble in water.

LUDAMAR, a Moorish kingdom in the interior of Africa, of which the capital Benorm is placed by Major Rennel in 15° N. Lat. and 6° 50′ W. Long. It has for its northern boundary the great desert (see Sahara in this *Supplement*), and is described by Mr Park as little better than a desert itself. Our traveller was taken captive on the confines of this kingdom, and carried to the camp of the king, where he was subjected to

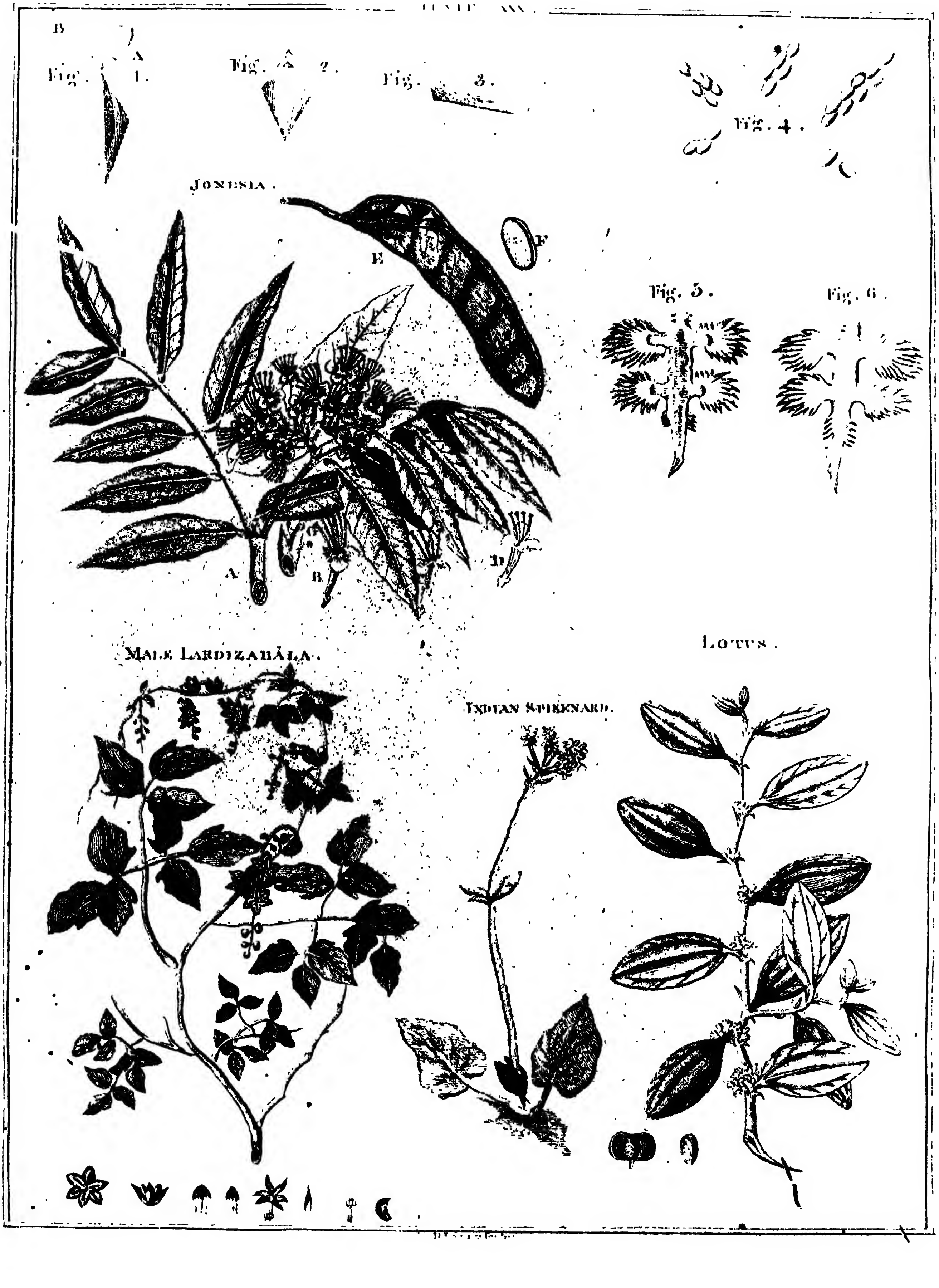


Fig. 1.
A
B
Fig. 2.
Fig. 3.
Fig. 4.
Jonesia.
E
F
Fig. 5.
Fig. 6.
A
B
D
Male Lardizabala.
Lotus.
Indian Spikenard.

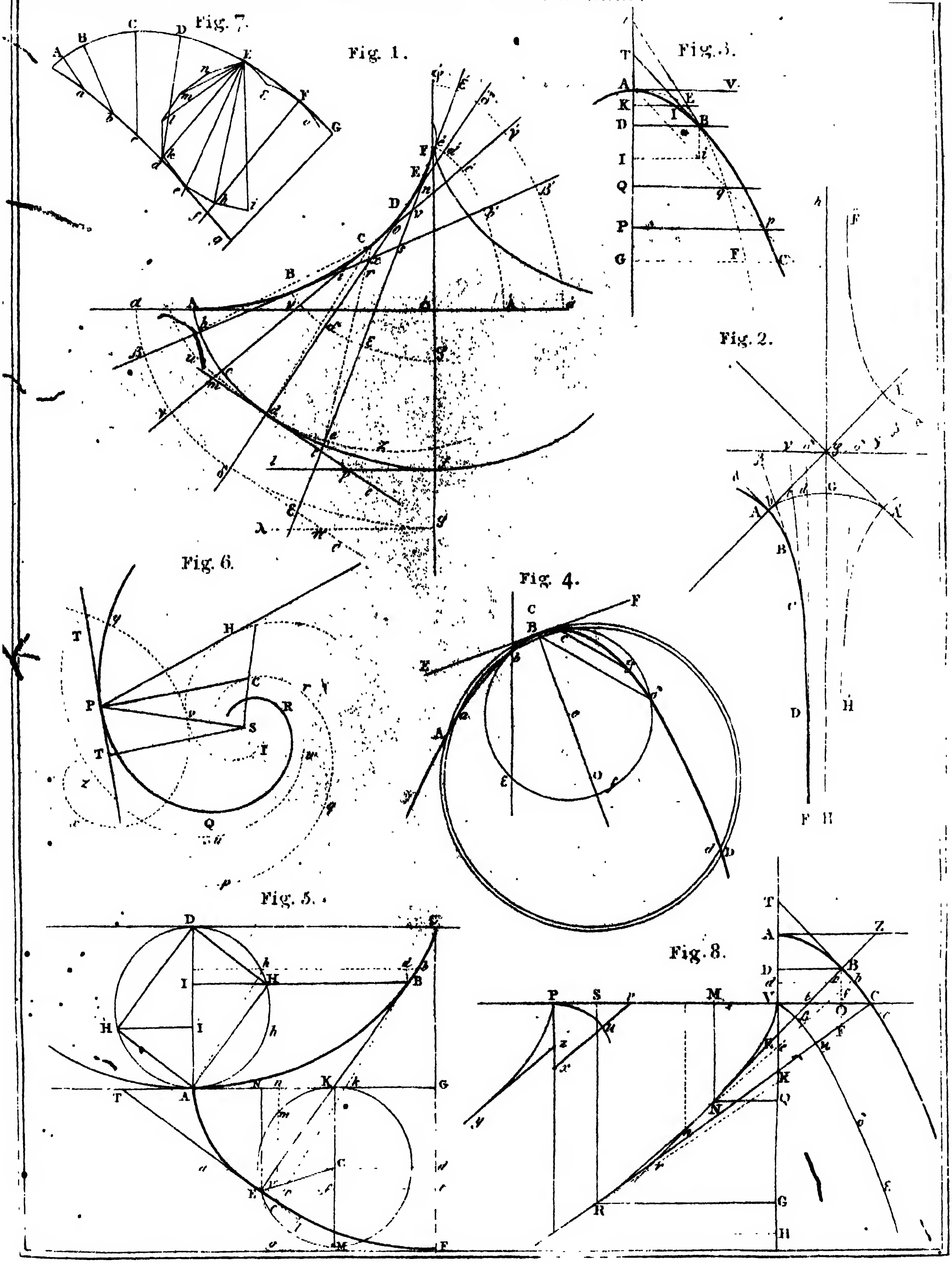


Fig. 7.
Fig. 1.
Fig. 3.
Fig. 2.
Fig. 6.
Fig. 4.
Fig. 5.
Fig. 8.

PLATE XXXII.

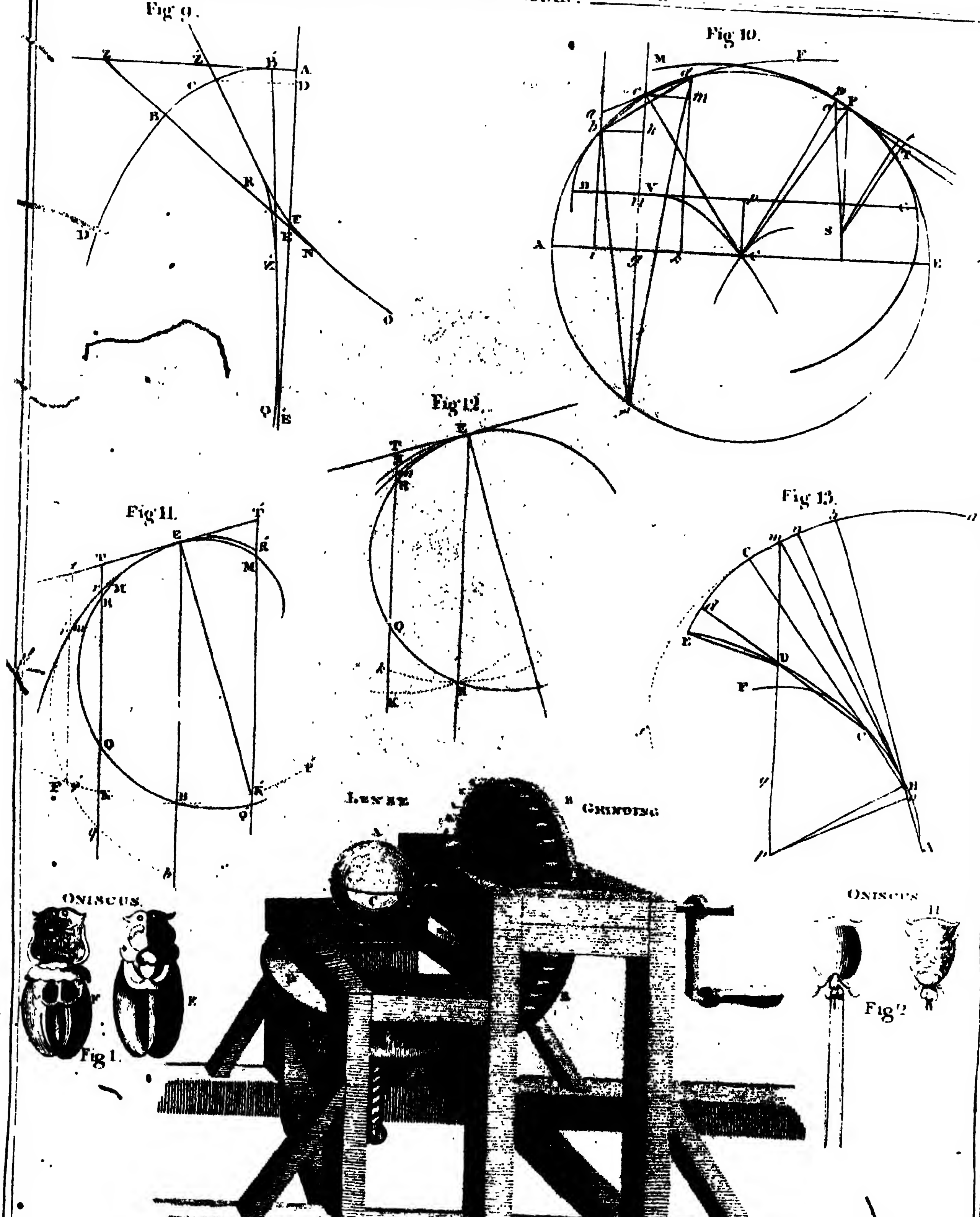


Fig 9.
Fig 10.
Fig 12.
Fig 11.
Fig 13.
LENSE GRINDING
ONISCUS.
Fig 1.
ONISCUS
Fig 2

Ludamar. to the cruelest indignities that the malice of bigotted Moors could invent. He was not suffered to travel beyond the camp; though he moved as it moved, and of course saw a considerable part of the country, and had an opportunity of observing the manners of the people. "The Moors of Ludamar subsist chiefly on the flesh of their cattle; and are always in the extreme of either gluttony or abstinence. In consequence of the frequent and severe fasts which their religion enjoins, and the toilsome journeys which they sometimes undertake across the desert, they are enabled to bear both hunger and thirst with surprising fortitude; but whenever opportunities occur of satisfying their appetite, they generally devour more at one meal than would serve an European for three. They pay but little attention to agriculture; purchasing their corn, cotton cloth, and other necessaries, from the Negroes, in exchange for salt, which they dig from the pits in the Great Desert.

"The natural barrenness of the country is such, that it furnishes but few materials for manufacture. The Moors, however, contrive to weave a strong cloth, with which they cover their tents; the thread is spun by their women from the hair of goats: and they prepare the hides of their cattle so as to furnish saddles, bridles, pouches, and other articles of leather. They are likewise sufficiently skilful to convert the native iron, which they procure from the Negroes, into spears and knives, and also into pots for boiling their food; but their sabres and other weapons, as well as their fire-arms and ammunition, they purchase from the Europeans, in exchange for the Negro slaves which they obtain in their predatory excursions. Their chief commerce of this kind is with the French traders on the Senegal river."

The Moors of this country have singular ideas of feminine perfection. The gracefulness of figure and motion, and a countenance enlivened by expression, are by no means essential points in their standard; with them corpulence and beauty appear to be terms nearly synonymous. A woman, of even moderate pretensions, must be one who cannot walk without a slave under each arm to support her; and a perfect beauty is a load for a camel. In consequence of this prevalent taste for unwieldiness of bulk, the Moorish ladies take great pains to acquire it early in life; and for this purpose many of the young girls are compelled by their mothers to devour an immense quantity of food, and drink a large bowl of camel's milk every morning. It is of no importance whether the girl has an appetite or not, the meat and the drink must be swallowed; and obedience is frequently enforced by blows. This singular practice, instead of producing indigestion and disease, soon covers the young lady with that degree of plumpness, which, in the eye of a Moor, is perfection itself.

"Although the wealth of the Moors consists chiefly in their numerous herds of cattle; yet, as the pastoral life does not afford full employment, the majority of the people are perfectly idle, and spend the day in trifling conversation about their horses, or in laying schemes of depredation on the Negro villages. L Lynx.

"The usual place of rendezvous for the indolent is the king's tent, where great liberty of speech seems to be exercised by the company towards each other. While in speaking of their chief, they express but one opinion. In praise of their sovereign, they are unanimous. Songs are composed in his honour, which the company frequently sing in concert; but they are so loaded with gross adulation, that no man but a Moorish despot could hear them without blushing. The king is distinguished by the fineness of his dress, which is composed of blue cotton cloth brought from Tombuctoo, or white linen or muslin from Morocco. He has likewise a larger tent than any other person, with a white cloth over it; but in his usual intercourse with his subjects, all distinctions of rank are frequently forgotten. He sometimes eats out of the same bowl with his camel driver, and reposes himself, during the heat of the day, upon the same bed.

"The military strength of Ludamar consists in cavalry. They are well mounted, and appear to be very expert in skirmishing and attacking by surprise. Every soldier furnishes his own horse, and finds his accoutrements, consisting of a large sabre, a double barrelled gun, a small red leather bag for holding his balls, and a powder horn slung over the shoulder. He has no pay, nor any remuneration but what arises from plunder. This body is not very numerous; for when Ali the king made war upon Bambara, our author was informed that his whole force did not exceed 2000 cavalry. They constitute, however, by what he could learn, but a very small proportion of his Moorish subjects. The horses are very beautiful, and so highly esteemed, that the Negro princes will sometimes give from twelve to fourteen slaves for one horse."

Cut off from all intercourse with civilized nations, and boasting an advantage over the Negroes, by possessing, though in a very limited degree, the knowledge of letters, the Moors of Ludamar are at once the vainest and proudest, and perhaps the most bigotted, ferocious, and intolerant of all the nations on the earth; combining in their character the blind superstition of the Negro with the savage cruelty and treachery of the Arab. It was with the utmost difficulty that our author made his escape from this inhospitable people.

LUPUS, the *Wolf*, a southern constellation, joined to the Centaur, containing together 19 stars in Ptolomy's catalogue, but 24 in the Britannic catalogue.

LYNX, a constellation of the northern hemisphere, composed by Hevelius out of the unformed stars. In his catalogue it consists of 19 stars, but in the Britannic 44.

M.

MACHINERY.

THE denomination *Machine* is now vulgarly given to a great variety of subjects, which have very little analogy by which they can be classed with propriety under any one name. We say a travelling machine, a bathing machine, a copying machine, a threshing machine, an electrical machine, &c. &c. The only circumstance in which all these agree seem to be, that their construction is more complex and artificial than the utensils, tools, or instruments which offer themselves to the first thoughts of uncultivated people. They are more artificial than the common cart, the bathing tub, or the flail. In the language of ancient Athens and Rome, the term was applied to every tool by which hard labour of any kind was performed; but in the language of modern Europe, it seems restricted either to such tools or instruments as are employed for executing some philosophical purpose, or of which the construction employs the simple mechanical powers in a conspicuous manner, in which their operation and energy engage the attention. An electrical machine, a centrifugal machine, are of the first class; a threshing machine, a fire machine, are of the other class. It is nearly synonymous, in our language, with ENGINE; a term altogether modern, and in some measure honourable, being bestowed only, or chiefly, on contrivances for executing work in which ingenuity and mechanical skill are manifest. Perhaps, indeed, the term *engine* is limited, by careful writers, to machines of considerable magnitude, or at least of considerable art and contrivance. We say, with propriety, steam engine, fire-engine, plating-engine, boring-engine; and a dividing machine, a copying machine, &c. Either of these terms, *machine* or *engine*, are applied with impropriety to contrivances in which some piece of work is not executed on materials which are then said to be manufactured. A travelling or bathing machine is surely a vulgarism. A machine or engine is therefore a TOOL; but of complicated construction, peculiarly fitted for expediting labour, or for performing it according to certain invariable principles: And we should add, that the dependence of its efficacy on mechanical principles must be apparent, and even conspicuous. The contrivance and erection of such works constitute the profession of the engineer; a profession which ought by no means to be confounded with that of the mechanic, the artisan, or manufacturer. It is one of the *artes liberales*; as deserving of the title as medicine, surgery, architecture, painting, or sculpture. Nay, whether we consider the importance of it to this flourishing nation, or the science that is necessary for giving eminence to the professor, it is very doubtful whether it should not take place of the three last named, and go *pari passu* with surgery and medicine. The inconsiderate reader, who peruses *Cicero de Oratore* with satisfaction, is apt to smile at Vitruvius, who requires in his architect nearly the same accomplishments which Cicero requires in his orator. He has not recollected, or perhaps did not know, that the profession of an architect in the Augustan age was the most respectable of all those which were not essentially connected with the management of state affairs. It appears that the architects were all Greeks, or the pupils of Greeks, altogether different from the members of the *Collegium Murariorum*, the corporation of builders and masons. The architecture of temples, stadiums, circuses, amphitheatres, seems to have been monopolised, by state authority, by a society which had long subsisted in Asia, connected by certain mysterious bonds, both civil and religious. We find it in Syria; and we learn that it was brought thither from Persia in very ancient times. From thence it spread into Ionia, where it became a very eminent and powerful association, under the particular protection of Bacchus, to whom the members had erected a magnificent temple at Teos, with a vast establishment of priests and priestesses, consisting of persons of the first rank in the state. They were the sole builders of temples and stadiums throughout all Greece and the Lesser Asia; and the contractors for the machinery that was employed in the theatres, and in the great temples, for the celebration of the high mysteries of paganism. By the imperfect accounts which remain of the Eleusinian and other mysteries, it appears, that this machinery must have been immense and wonderful, and must have required a great deal of mechanical skill. This indeed appears, in the most convincing manner, to any person who reflects on the magnificent structures which they erected, which excite to this day the wonder of the world, not only on account of their magnificence and incomparable elegance, but also on account of the mechanical knowledge that seems indispensably necessary for their erection. This will ever remain a mystery. There are no traces of such knowledge to be found in the writings of antiquity. Even Vitruvius, writing expressly on the subject, has given us nothing but what is in the lowest degree of elementary knowledge.

This association of the Dyonisiacs undoubtedly kept their mechanical science a profound secret from the uninitiated, the profane. They were the engineers of antiquity, and Vitruvius was perhaps not one of the initiated. He speaks of Myro and other Greek architects in terms of respect which border on veneration. Perhaps the modern association of free masons is a remain of this antient fraternity, continued to our times by the company of builders, who erected the cathedrals and great conventual churches. No one who considers their works with scientific attention, can doubt of their being deeply versed in the principles of mechanics, and even its more refined branches. They appear to have carried the art of vault-roofing almost to its acmé of perfection; far outstripping their Grecian instructors in their knowledge of this most delicate branch of their art.

It were greatly to be wished that some such institution did yet exist, where men might be induced by the most powerful motives to accomplish themselves in the knowledge necessary for attaining eminence in their profession.

We have been informed (and we thought our authority good), that our gracious Sovereign has signified his intention of patronising an institution of this kind. We heard, that it was proposed to institute degrees similar to our university degrees, and proceeding on similar conditions of a regular education or standing, which would ensure the *opportunities* of information, and also on an examination of the proficiency of the candidate. This examination, being conducted by persons eminent in the profession, perhaps still exercising it, would probably be serious, because the successful candidate would immediately become a rival practitioner. Such an institution would undoubtedly prevent many gross impositions by unlettered mill-wrights and pump-makers, who now seldom appear under any name but that of engineer, although they are frequently ignorant even of the elements of mechanical science, and are totally unacquainted with the higher mathematics; without which it is absolutely impossible for them to contrive a machine well suited to the intended purpose, or to say with any tolerable precision what will be the performance of the engine they have erected. Yet these are questions susceptible of accurate solution, because they depend on the unalterable laws of matter and motion.

All who have a just view of the unspeakable advantages which this highly favoured land possesses in the superiority and activity of its manufactures, and who know how much of this superiority should be ascribed to the great improvements which have been made in practical mechanics within these last thirty years, will join us in wishing success to some such institution as that now mentioned.

We were naturally led to these reflections when we turned our thoughts to machinery in general, and observed what is done in this country by the native energy of its inhabitants, unassisted by such scientific instructions as they might have expected from the pupils of a Newton, their countryman, under the patronage of the best of Sovereigns, eminently knowing in these things, and ever ready to encourage those sciences and arts which have so highly contributed to the national prosperity. What might not be reasonably expected from British activity, if those among ourselves who have knowledge and leisure had been at the same pains with the members of the foreign academies to cultivate the Newtonian philosophy, and particularly the more refined branches of mechanics, and to deduce from their speculations maxims of construction fitted to our situation as a great manufacturing nation? But such knowledge is not attainable by those who are acquainted only with the imperfect elements contained in the publications read by the bulk of our practitioners. Much to this purpose has been done on the continent by the most eminent mathematicians; but from want of individual energy, or perhaps of general security and protection, the patriotic labours of those gentlemen have not done the service to their country which might have been reasonably expected. Indeed, their dissertations have generally been so composed, that only the learned could see their value. They seem addressed only, or chiefly, to such; but it is to those authors that our countrymen generally have recourse for information concerning every thing in their profession that rises above mere elementary knowledge. The books in our language which profess to be systems of mechanics rarely go beyond this: they contain only the principles of equilibrium. These are absolutely necessary for the knowledge of machines; but they are very far indeed from giving what may be called a practical knowledge of *working machinery*. This is never in a state of equilibrium. The machine must move in order to work. There must be a superiority of impelling power, beyond what is merely sufficient for balancing the resistance or contrary action of the work to be performed. The reader may turn to the article STATICS in the *Encyclopædia Britannica*, and he will there see some farther observations on this head. And in the article MECHANICS he will find a pretty ample detail of all the usual doctrines, and a description of a considerable variety of machines or engines, accompanied by such observations as are necessary for tracing the propagation or transmission of pressure from that part of the machine to which the natural power is applied to the working part of the machine. Along with these two articles, it will be proper to read with peculiar attention the article ROTATION.

By far the greatest number of our most serviceable engines consist chiefly of parts which have a motion of rotation round fixed axes, and derive all their energy from levers virtually contained in them. And these acting parts are also material, requiring force to move them, over and above what is necessary for producing the acting force at the working part of the machine. The modifications which this circumstance frequently makes of the whole motions of the machine, are indicated in the article ROTATION in an elementary way; and the propositions there investigated will be found almost continually involved in the complete theory of the operation of a machine. Lastly, it will be proper to consider attentively the propositions contained in the article *Strength of Materials*, that we may combine them with those which relate wholly to the working of the machine; because it is from this combination only that we discover the strains which are excited at the various points of support, and of communication, and in every member of the machine. We suppose all these things already understood.

Our object at present is to point out the principles which enable us to ascertain what will be the precise motion of a machine of given construction, when actuated by a natural power of known intensity, applied to a given point of the machine, while it is employed to overcome a known resistance acting at another point. To abbreviate language, we shall call that the IMPELLED POINT of the machine to which the pressure of the moving power is immediately applied; and we may call that the WORKING POINT, where the resistance arising from the work to be performed immediately acts. The chief question in mechanics.

To consider this important subject, even in its chief varieties, requires much more room than can be allowed in an undertaking like ours, and therefore we must content ourselves with a very limited view; but at the same time, such a view as shall give sufficient indication of the principles which should direct the practical reader in every important case. We shall consider those machines which

which perform their motions round fixed axes; these being by far the most numerous and important, because they involve in their construction and operations all the leading principles.

2 The proper measure of mechanical power exerted.

That we may proceed securely, it is necessary to have a precise and adequate notion of moving force, as applied to machinery, and of its measures. We think this peculiarly necessary. Different notions have been entertained on this subject by Mr Leibnitz, Des Cartes, and other eminent mechanicians of the last century; and their successors have not yet come to an agreement. Nay, some of the most eminent practitioners of the present times (for we must include Mr Smeaton in the number) have given measures of mechanical power in machinery which we think inaccurate, and tending to erroneous conclusions and maxims.

We take for the measure (as it is the effect) of exerted mechanical power the quantity of motion which it produces by its uniform exertion during some given time. We say *uniform exertion*, not because this uniformity is necessary, but only because, if any variation of the exertion has taken place, it must be known, in order to judge of the power. This would needlessly complicate the calculations; but in whatever way the exertion may have varied, the whole accumulated exertion is still accurately measured by the quantity of motion existing at the end of the exertion. The reader must perceive that this is the same thing that is expressed in the article DYNAMICS of this *Supplement*, n° 90. by the area of the figure whose abscissa or axis represents the time of exertion; and the ordinates are as the pressures in the different instants of that time, the whole being multiplied by the number of particles (that is, by the quantity of matter), because that figure represents the quantity of motion generated in one particle of matter only. All this is abundantly clear to persons conversant in these disquisitions; but we wish to carry along with us the distinct conceptions of that useful class of readers whose profession engages them in the construction and employment of machines, and to whom such discussions are not so familiar. We must endeavour therefore to justify our choice of this measure by appealing to familiar facts.

If a man, by pressing uniformly on a mass of matter for five seconds, generates in it the velocity of eight feet per second, we obtain an exact notion of the proportion of this exertion to the mechanical exertion of gravity, when we say that the man's exerted force has been precisely one-twentieth part of the action of gravity on it; for we know that the weight of that body (or, more properly, its heaviness) would, in five seconds, have given it the velocity of 160 feet per second, by acting on it during its fall. But let us attend more closely to what we mean by saying that the exerted force is one-twentieth of the exertion of gravity. The only notion we have of the exertion of gravity is what we call the weight of the body—the pressure which we feel it make on our hand. To say that this is 20 pounds weight, does not explain it; because this is only the action of gravity on another piece of matter. Both pressures are the same. But if the body weighs 20 pounds, it will draw out the rod of a steelyard to the mark 20. The rod is so divided, that the 20th part of this pressure will draw it out to 1. Now the fact is, that if the man presses on the mass of 20 pounds weight with a spring steelyard during five seconds, and if during that time the rod of the steelyard was always at the mark 1, the body will have acquired the velocity of eight feet per second. This is an acknowledged fact. Therefore we were right in saying, that the man's exertion is one-twentieth of the exertion of gravity. And since we believe the weight of bodies to be proportional to their quantity of matter, all matter being equally heavy, we may say, that the man's exertion was equal to the action of gravity on a quantity of matter whose weight is one pound. We express it much more familiarly, by saying, that the man exerted on it the pressure of one pound of matter, or the force of one pound.

In this manner, the motion communicated to a mass of matter, by acting on it during some time, informs us with accuracy of the real mechanical force or pressure which has been exerted. This is judged to be double when twice the velocity has been generated in the same mass, or where the same velocity has been generated in twice the mass; because we know, that a double pressure would have done either the one or the other.

But farther: We know that this pressure is the exertion; we have no other notion of our own force; and our notion of gravity, of elasticity, or any other natural force, is the same. We also know that the continuance of this exertion fatigues and exhausts our strength as completely as the most violent motion. A dead pull, as it is called, of a horse, at a post fixed in the ground, is a usual trial of his strength. No man can hold out his arm horizontally for much more than a quarter of an hour; and the exertion of the last minutes gives the most distressing fatigue, and disables the shoulder from action for a considerable time after. This is therefore an expenditure of mechanical power, in the strict primitive sense of the word. Of this expenditure we have an exact and adequate effect and measure in the quantity of motion produced; that is, in the product of the quantity of matter by the velocity generated in it by this exertion. And it must be particularly noticed, that this measure is applicable even to cases where no motion is produced by the exertion; that is, if we know that the exertion which is just unable to start a block of stone lying on a smooth stone pavement, but would start it, if increased by the smallest addition; and if we know that this would generate in a second 32 feet of velocity in 100 pounds of matter—we are certain that it was a pressure equal to the weight of this 100 pounds. It is a good measure, though not immediate, and may be used without danger of mistake when we have no other.

The celebrated engineer Mr Smeaton, in his excellent dissertation on the power of water and wind to drive machinery, and also in two other dissertations, all published in the Philosophical Transactions, and afterwards in a little volume, has employed another measure, both of the expenditure of mechanical power, and of the mechanical effect produced. He says, that the weight of a body, multiplied by the height thro' which it descends, while driving a machine, is the only proper measure of the power expended; and that the weight, multiplied by the height through which it is uniformly raised, is the only proper measure of the effect produced. And he produces a large train of accurate experiments

3 Mr Smeaton's measure

riments to prove that a certain weight, descending through a certain space, always produces the same effect, whether it has descended swiftly or slowly, employing little or much time.

Had this eminent engineer proposed this as a popular measure, of easy comprehension and remembrance, and as well accommodated to the uses of those engaged in the construction of machines, when restricted to a certain class of cases, it might have answered very good purposes; but the author is at pains to recommend it to the philosophers as a necessary correction of their theories, which he says tend to mislead the artists. His own reasonings terminate in the same conclusion with Mr Leibnitz's, namely, that the power of producing a mechanical effect, and the effect produced, are proportional to the square of the velocity. The deference justly due to Mr Smeaton's authority, and the influence of his name among those who are likely to make the most use of his instructions, render it necessary for us to examine this matter with some attention.

Mr Smeaton was led to the adoption of this measure by his professional habits. Raising a weight to a height is, in one shape or another, the general task of the machines he was employed to erect; and we may add, the opportunities of expending the mechanical powers of nature which are in our command, are generally in this proportion. A certain daily supply of water, coming from a certain height, is our best opportunity, and may very properly be said to be expended.

[4] zamined,

This being the general case, the measure was obvious, and natural, and good. The power and effect were of the same kind, and *must* be measures of each other; at least, in those circumstances in which they were set in op[position]. Yet even here Mr Smeaton was obliged to [mak]e a restriction of his measures. "The height thro' which a body *slowly and equably* descended, or to which it was raised." And why was this limitation necessary? "Because in rapid or accelerated motions, the inertia of bodies occasioned some variation*." But this is too vague language for philosophical disquisition. Besides, what is meant by this variation? What is the standard from which the unrestricted measure varies? This standard, whatever it is, is the true measure, and it was needless to adopt any other. Now, the standard from which Mr Smeaton estimates the deviation, is the very measure which we wish to employ, namely, the quantity of motion produced. Strictly speaking, even this is not the immediate measure. The immediate measure is that faculty which we call pressure. This is the intermedium perceivable in all productions of motion; and it is also the intermedium of mechanical effect, even when motion is not produced; as when the weight of a body bends a spring, or the elasticity of a body supports another pressure. How it operates in all or any of these cases, we know not: but we know that all these measures of pressure agree with each other. A double quantity of motion will bend a spring doubly strong, will raise a double weight, will withstand any double pressure, &c &c. In short, pressure is the immediate agent in every mechanical phenomenon. It penetrates bodies, overcoming their tenacity; it overcomes friction; it balances pressure; it produces motion. Mr Smeaton's measure is only nearly true, in any case, and in all cases it is far from being exact in the first instants of the motion, during its acceleration or retardation.

* Page 7.

We have already noticed the complete expenditure of animal power by continued pressure, even when motion is not produced: the only difficulty is to connect this in a measurable way with the power which the same exertion has of generating motion in a body.

When a man supports a weight for a single instant, he certainly balances the pressure or action of gravity on that body; and he continues this action as long as he continues to support it: and we know that if this body were at the end of a horizontal arm turning round a vertical axis, the same effort which the man exerted in merely carrying the weight, if now exerted on the body, by pushing it horizontally round the axis, will generate in it the same velocity which gravity would generate by its falling freely. On this authority therefore we say, that the whole accumulated action of a man, when he has just carried a body whose weight is 30 pounds for one minute, is equal to the whole exertion of gravity on it during that minute; and if employed, not to counteract gravity, but to generate motion, would generate, during that minute, the same motion that gravity would, that is, 60 × 32 feet velocity per second, in a mass of 30 pounds. There would be 30 pounds of matter moving with the velocity of 1920 feet per second. We would express this production or effect by 30 × 1920, or by 57600, as the measure of the man's exertion during the minute.

But, according to Mr Smeaton, there is no expenditure of power, nor any production of mechanical effect, in thus carrying 30 pounds for a minute; there is no product of a weight by a height through which it is equably raised; yet such exertion will completely exhaust a man's strength if the body be heavy enough. Here then is a case to which Mr Smeaton's measure does not readily apply; and this case is important including all the actions of animals at a dead pull.

But let us consider more narrowly what a man really does when he performs what Mr Smeaton allows to be the production of a measurable mechanical effect. Suppose this weight of 30 pounds hanging by a cord which passes over a pulley, and that a man, taking this cord over his shoulder, turns his back to the pulley, and walks away from it. We know, that a man of ordinary force will walk along, raising this weight, at the rate of about 60 yards in a minute, or a yard every second, and that he can continue to do this for eight or ten hours from day to day; and that this is all that he can do without fatigue. Here are 30 pounds raised uniformly 180 feet in a minute; and Mr Smeaton would express this by 30 × 180, or 5400, and would call this the measure of the mechanical effect, and also of the expenditure of power. This is very different from our measure 57600.

But this is not an accurate and complete account of the man's *action* on the weight, and of the whole effect produced. To be convinced of this, suppose that a man A has been thus employed, while another B, walking along side of him at the same rate, suddenly takes the rope out of his hand, frees him of the task, and *continues* to raise the weight without the smallest change on its velocity of ascent. What is the action of B, and whether is it the same with that of A or not? It is acknowledged by all, that the exertion of B against the load is precisely equal to 30 pounds. If he holds the rope by a spring steelyard, it will stand constantly at the mark 30. B exerts the same action on the load as when

[5] And found to be inaccurate.

when he firmly supports it from falling back into the pit. It was moving with the velocity of three feet per second when he took hold of the rope, and it would continue to move with that velocity if any thing could annihilate or counteract its gravity. If therefore there was no action when a person merely carried it, there is none at present when it is rising 180 feet in a minute. The man does indeed work more than on that occasion, but not against the load: his additional work is walking, the motion of his own body, as a thing previously necessary that he may continue to support the load, that he may continue his mechanical effort as it follows him. It appears to yield to him: but it is not to *his* efforts that it yields; its weight completely balances those efforts, and is balanced by them. It was to a *greater* effort of the man A that it yielded. It was then lying on the ground. He pulled at the cord, gradually perhaps increasing his pull till it was just equal to its weight. When this obtains, the load no longer presses on the ground, but is completely carried by the rope. But it does not move by this effort of 30 pounds; but let him exert a force of 31 pounds, and continue this for three seconds. He will put it in motion; will accelerate that motion; and at the end of three seconds the load is rising with the velocity of three feet per second. The man feels that this is as much speed as he can continue in his walk; he therefore slackens his pull, reducing his action to 30 pounds, and with this action he walks on. All this would be distinctly perceived by means of a steelyard. The rod would be pulled out beyond 30, till the load acquired the uniform velocity intended, and after this it would be observed to shrink back to 30.

More is done therefore than appears by Mr Smeaton's measure. Indeed, all that appears in it is the exertion necessary for *continuing* a motion already produced, but which would be immediately extinguished by a contrary power, which must therefore be counteracted. This measure will not apply to numberless cases of the employment of machines, where there is no such opposing power, and where, notwithstanding, mechanical power must be expended, even according to Mr Smeaton's measurement. Such are corn mills, boring mills, and many others.

How then comes it that Mr Smeaton's valuable experiments concur so exactly in shewing that the same quantity of water descending from the same height, always produces the same effect (as he measured it), whatever be the velocity? In the first place, all his experiments are cases where the power expended and the work performed are of the same kind: A heavy body descends, and by its preponderancy raises another heavy body. But even this would not ensure the precise agreement observed in his experiments, if Mr Smeaton were not careful to exclude from his calculations all that motion where there is any acceleration, and all the expenditure of water during the acceleration, and to admit only those motions that are sensibly uniform. In moderate velocities, the additional pressure required for the first acceleration is but an insignificant part of the whole; and to take these accelerated motions into the account, would have embarrassed the calculations, and perhaps confused many of the readers. We see, in the instance now given, that the addition of one pound continued for three seconds only, was all that was necessary.

Mr Smeaton's measurement is therefore abundantly exact for practice; and being accommodated to the circumstances most likely to engage the attention, is very proper for the instruction of the numerous practitioners in all manufacturing countries who are employed for ordinary erections: but it is improperly proposed as an article essential to a just theory of mechanics, and therefore it was proper to notice it in this place. Besides, there frequently occur most important cases, in which the motion of a machine is, of necessity, desultory, alternately accelerated, and retarded. We should not derive all the advantages in our power from the first mover, if we did not attend particularly, and chiefly, to the *accelerating* forces. And in every case, the improvement, or the proper employment of the machine, is not attained, if we are not able to discriminate between the two parts of the mechanical exertion; one of them, by which the motion is produced and accelerated to a certain degree; and the other, by which that motion is continued. We must be able to appreciate what part of the effect belongs to each.—But it is now time to proceed to the important question,

What will be the precise motion of a machine of given construction, actuated by a power of known intensity and manner of acting, and opposed by a known resistance?

In the solution of this question, much depends on the nature of both power and resistance. In the statical consideration of machines, no attention is paid to any differences. The intensity of the pressures is all that it is necessary to regard, in order to state the proportion of pressure which will be exerted in the various parts of the machine. The pressures at the impelled and working points, combined with the proportions of the machine, necessarily determine all the rest. Pressure being the sole cause of all mechanical action among bodies, any pressure may be substituted for another that is equal to it; and the pressure which is most familiar, or of easiest consideration, may be used as the representative of all others. This has occasioned the mechanical writers to make use of the pressure of gravity as the standard of comparison, and to represent all powers and resistances by weights. However proper this may be in their hands, it has hurt the progress of the science. It has rendered the usual elementary treatises of mechanics very imperfect, by limiting the experiments and illustrations to such as can be so represented with facility. This has limited them to the state of equilibrium (in which condition a working machine is never found), because illustrations by experiment out of this state are neither obvious nor easy. It has also prevented the students of mechanics from accomplishing themselves with the mathematical knowledge required for a successful prosecution of the study. The most elementary geometry is sufficient for a thorough understanding of equilibrium, or the doctrines of statics; but true mechanics, the knowledge of machines as instruments by which work is performed, requires more refined mathematics, and is inaccessible without it.

Things to be considered in a machine at work.

Had not Newton or others improved mathematics by the invention of the infinitesimal analysis and calculus, we must have rested contented with the discoveries (really great) of Galileo and Huyghens. But Newton,

ton, *sui mathesi facem præferente*, opened a boundless field of investigation, and has not only given a magnificent and brilliant specimen of the discoveries to be made in it, but has also traced out the particular paths in which we are to find the solution of all questions of practical mechanics. This he has done by shewing another species of equilibrium, indicated, not by the cessation of all motion, but by the uniformity of motion; by the cessation of all acceleration or retardation. As the extinction of motion by the action of opposite forces is assumed by us as the indication of the perfect equality of those forces; so the extinction of acceleration should be received as the indication of something equal and opposite to the force which was known to have caused the acceleration; and therefore as the indication of an equilibrium between opposite forces, or else of the cessation of all force.

7 Mechanical equilibrium. This new view of things was the source of all our distinct notions of mechanical forces, and gave us our only unexceptionable marks and measures of them. The 39th proposition of the first book of Newton's Principles of Natural Philosophy, and its corollaries, contain almost the whole doctrine of active mechanical nature, and are peculiarly applicable to our present purpose, because they enable us to comprehend in this *mechanical equilibrium* (so different from the *statical*) every circumstance in which those pressures which are exerted by natural powers differ from each other, and vary in their action on the impelled and working points of a machine. Indeed, when we recollect that the operations of our machines are the same on board a ship as on shore, and that all our machines are moving with the ground on which they stand, we must acknowledge, that even ordinary statics is only an imperfect view of an equilibrium among things which are in motion; and this should have taught us that, even in those cases where nothing like equilibrium appears, an equilibrium may still be usefully traced.

8 Distinctions must be made in the nature of the powers applied to working machines. In the statical consideration of machines, the *quantity* of pressure is all that we need attend to. But in the mechanical discussion of their *operations*, we must attend to their distinctions in kind; and it will by no means be sufficient to represent them all by weights; for their distinction in kind is accompanied by great differences in their manner of acting on the machine. Some natural powers, in order to continue their action on the impelled point of the machine, must at the same time put into motion a quantity of matter external to the machine, in which these powers reside; and this must be made to follow the impelled point in its motion, and not only follow, but continue to press it forward; or, this matter, thus continually put into motion, must be successively applied to different points of the machine, which become impelled points in their turn. This is the case with a weight, with the action of a spring, the action of animals, the action of a stream of water or wind, and many other powers. A part of the natural mechanical powers must therefore be employed in producing this external motion. This is sometimes a very considerable part of the whole natural power. In some cases it is the whole of it. This obtains in the action of a descending weight, lying on the end of a lever and pressing it down, or hanging by a chord attached to the machine.

There is also an important distinction in the manner in which this external motion is kept up. In a weight employed as the moving power, the actuating pressure seems to reside in the matter itself; and all that is necessary for continuing this pressure is merely to continue the connection of it with the machine. But in the action of animals it may be very different: A man pushing at a capstan bar, must first of all walk as fast as the bar moves round, and this requires the expenditure of his muscular force. But this alone will not render his action an effective power: He must also *press forward* the capstan bar with as much force as he has remaining over and above what he expends in walking at that rate. The proportion of these two expenditures may be very different in different circumstances; and in the judicious selection of such circumstances as make the first of these as inconsiderable as possible, lies much of the skill and sagacity of the engineer. In the common operation of thrashing corn, much more than half of the man's power is expended in giving the necessary motion to his own body, and only the remainder is employed in urging forward the swiple with a momentum sufficient for shaking off the ripe grains from the stalk. We had sufficient proof of this, by taking off the swiple of the flail, and putting the same weight of lead on the end of the staff, and then causing the hind to perform the usual motions of thrashing with all the rapidity that he could continue during the ordinary hours of work. We never could find a man who could make three motions in the same time that he could make two in the usual manner, so as to continue this for half an hour. Hence we must conclude, that half (some will say two thirds) of a thrasher's power is expended in merely moving his own body. Such modes of animal action will therefore be avoided by a judicious engineer; but to be avoided, their inconvenience must be understood. More of this will occur hereafter.—In other cases, we are almost (never wholly) free from this unprofitable expenditure of power. Thus, in the steam engine, the operation requires that the external air follow the piston down the cylinder, in order to continue its pressure. But the force necessary for sending in this rare fluid into the cylinder with the necessary velocity, is such an insignificant part of the whole force which is at our command, that it would be ridiculous affectation in any engineer to take it into account; and this is one great ground of preference to this natural power. The same thing may be said of the action of a strong and light spring, which is therefore another very eligible first mover for machinery. The ancient artillerists had discovered this, and employed it in their warlike engines.

We must also attend to the nature of the resistance which the work to be performed opposes to the motion of our machine. Sometimes the work opposes, not a simple obstruction, but a real resistance or reaction, which, if applied alone to the machine, would cause it to move the contrary way. This always obtains in cases where a heavy body is to be raised, where a spring is to be compressed, and in some other cases. Very often, however, there is no such contrary action. A flour mill, a saw mill, a boring mill, and many such engines, exhibit no reaction of this kind. But although such machines, when at rest or not impelled by the first mover, sustain no pressure in the opposite direction, yet they

they will not acquire any motion whatever, unless they be impelled by a force of a certain determinate intensity. Thus in a saw mill, a certain force must be impressed on the teeth of the saw, that the cohesion of the fibres of the timber may be overcome. This requires that a certain force, determined by the proportions of the machine, be impressed on the impelled point. If this, and no more, be applied there, a force will be excited at the teeth of the saw, which will *balance* the cohesion of the wood, but will not *overcome* it. The machine will continue at rest, and no work will be performed. Any addition of force at the impelled point, will occasion an addition to the force excited in the teeth of the saw. The cohesion will be overcome, the machine will move, and work will be performed. It is only this *addition* to the impelling power that gives motion to the machine; the rest being expended merely in balancing the cohesion of the woody fibres. While therefore the machine is in motion, performing work, we must consider it as actuated by a force impressed on the impelled point by the natural power, and by another acting at the working point, furnished by or derived from the resistance of the work.

Again: It not unfrequently happens, that there is not even any such resistance or obstruction excited at the working point of the machine; the whole resistance (if we can with propriety give it that name) arises from the necessity of giving motion to a quantity of inert and inactive matter. This happens in urging round a heavy fly, as in the coining press, in the punching engine, in drawing a body along a horizontal plane without friction, and a few similar cases. Here the smallest force whatever, applied at the impelled point, will begin motion in the machine; and the *whole* force so applied is consumed in this service. Such cases are rare, as the ultimate performance of a machine; but occasionally, and for a farther purpose, they frequently occur; and it is necessary to consider them, because there are many of the most important applications of machinery where a very considerable part of the force is expended in this part of the general task.

Such are the chief circumstances of distinction among the mechanical powers of nature which must be attended to, in order to know the motion and performance of a machine. These never occur in the statical consideration of the machine, but here they are of chief importance.

9 The iner[illegible] of the m[illegible] [illegible] be con[illegible]si-dered,

But farther: The action of the moving power is transferred to the working point through the parts of a machine, which are material, inert, and heavy. Or, to describe it more accurately, before the necessary force can be excited at the working point of the machine, the various connecting forces must be exerted in the different parts of the machine; and in order that the working point may follow out the impression already made, all the connecting parts or limbs of the machine must *be moved*, in different directions, and with different velocities. Force is necessary for thus changing the state of all this matter, and frequently a very considerable force. Time must also elapse before all this can be accomplished. This often consumes, and really wastes, a great part of the impelling power. Thus, in a crane worked by men walking in a wheel, it acquires motion by slow degrees; because, in order to give sufficient room for the action of the number of men or cattle that are necessary, a very capacious wheel must be employed, containing a great quantity of inert matter. All of this must be put in motion by a very moderate preponderance of the men. It accelerates slowly, and the load is raised. When it has attained the required height, all this matter, now in considerable motion, must be stopped. This cannot be done in an instant with a jolt, which would be very inconvenient, and even hurtful; it is therefore brought to rest gradually. This also consumes time; nay, the wheel must get a motion in the contrary direction, that the load may be lowered into the cart or lighter. This can only be accomplished by degrees. Then the tackle must be lowered down again for another load, which also must be done gradually. All this wastes a great deal both of time and of force, and renders a walking wheel a very improper form for the first mover of a crane, or any machine whose use requires such frequent changes of motion. The same thing obtains, although in a lower degree, in the steam engine, where the great beam and pump rods, sometimes weighing very many tons, must be made to acquire a very brisk motion in opposite directions twice in every working stroke. It obtains, in a greater or a less degree, in all engines which have a reciprocating motion in any of their parts. Pump mills are of necessity subjected to this inconvenience. In the famous engine at Marly, about [illegible] of the whole moving power of some of the water wheels is employed in giving a reciprocating motion to a set of rods and chains, which extend from the wheels to a cistern about three-fourths of a mile distant, where they work a set of pumps. This engine is, by such injudicious construction, a monument of magnificence, and the struggle of ignorance with the unchangeable laws of Nature. In machines, all the parts of which continue the direction of their motions unchanged, the inertia of a great mass of matter does no harm; but, on the contrary, contributes to the steadiness of the motion, in spite of small inequalities of power or resistance, or unavoidable irregularities of force in the interior parts. But in all reciprocations, it is highly prejudicial to the performance; and therefore constructions which admit such reciprocation without necessity, are avoided by all intelligent engineers. The mere copying artist, indeed, who derives all his knowledge from the common treatises of mechanics, will never suspect such imperfections, because they do not occur in the statical consideration of machines.

10 And its friction.

Lastly, no machine can move without a mutual rubbing of its parts, at all points of communication; such as the teeth of wheelwork, the wipers and lifts, and the gudgeons of its different axes. In many machines, the ultimate task performed by the working point, is either friction, or very much resembles it. This is the case in polishing mills, grinding mills, nay in boring mills, saw mills, and others. A knowledge of friction, in all its varieties, seems therefore absolutely necessary, even for a moderate acquaintance with the principles of machinery. This is a very abstruse subject; and although a good deal of attention has been paid to it by some ingenious men, we do not think that a great deal has been added to our knowledge of it; nor do the experiments which have been made seem to us well calculated to lead us to a distinct knowledge of its nature and modifications. It has been considered chiefly with a view to diminish it as much as possible in the communicating parts

parts of machinery, and to obtain some general rules for ascertaining the quantity of what unavoidably remains. Mr Amontons, of the Royal Academy of Sciences at Paris, gave us, about the beginning of this century, the chief information that we have on the subject. He discovered, that the obstruction which it gave to motion was very nearly proportional to the force by which the rubbing surfaces are pressed together. Thus he found, that a smooth oaken board, laid on another smooth board of the same wood, requires a force nearly equal to one third of what presses the surfaces together. Different substances required different proportions.

Measure of it by Amontons.

He also found, that neither the extent of the rubbing surfaces, nor the velocity of the motion, made any considerable variation on the obstruction to motion. These were curious and unexpected results. Subsequent observations have made several corrections necessary in all these propositions. This subject will be more particularly considered in another place; but since the deviations from Mr Amontons's rule are not very considerable, at least in the cases which occur in this general consideration of machines, we shall make use of it in the mean time. It gives us a very easy method of estimating the effect of friction on machines. It is a certain proportion of the mutual pressure of the rubbing surfaces, and therefore must vary in the same proportion with this pressure. Now, we learn from the principles of statics, that whatever pressures are exerted on the impelled and working point of the machine, all the pressures on its different parts have the same constant proportion to these, and vary as these vary. Therefore the whole friction of the machine varies in the same proportion. But farther, since it is found that the friction does not sensibly change with the velocity, the force which is just sufficient to overcome the friction, and put the loaded machine in motion, must be very nearly the same with the force expended in overcoming the friction while the machine is moving with any velocity whatever, and performing work. Therefore if we deduct from the force which just puts the loaded machine in motion that part of it which balances the reaction of the impelled point occasioned by the resistance of the work, or which balances the resistance of the work, the remainder is the part of the impelling power which is employed in overcoming the friction. If indeed the actual resisting pressure of the work varies with the velocity of the working point, all the pressures, and all the frictions in the different communicating parts of the machine, vary in the same proportion. But the law of this variation of working resistance being known, the friction is again ascertained.

We can now state the dynamical equilibrium of forces in the working machine in two ways. We may either consider the efficient impelling power as diminished by all that portion which is expended in overcoming the friction, and which only prepares the machine for performing work, or we may consider the impelling power as entire, and the work as increased by the friction of the machine; that is, we may suppose the machine without friction, and that it is loaded with a quantity of additional resistance acting at the working point. Either of these methods will give the same result, and each has its advantages. We took the last method in the slight view which we took of this subject in the *Encycl.* art. ROTATION, n° 64. and shall therefore use it here.

Supposing now this previous knowledge of all these variable circumstances which affect the motion of machines of the rotative kind, so that, for any momentary position of it while performing work, we know what are the precise pressures acting at the impelled and working points, and the construction of the machine, on which depend the friction, and the momentum of its inertia (expressed in the article ROTATION by $\int p r^2$); we are now in a condition to determine its motion, or at least its momentary acceleration, competent to that position. Therefore,

14 Composition of the formula expressing the performance of a machine.

Let there be a rotative machine, so constructed, that while it is performing work, the velocity of its impelled point is to that of its working point as m to n. It is easy to demonstrate, from the common principles of statics, that if a simple wheel and axle be substituted for it, having the radius of the wheel to that of the axle in the same proportion of m to n, and having the same momentum of friction and inertia, and actuated by the same pressures at the impelled and working points, then the velocities of these points will be precisely the same as in the given machine.

Let p represent the intensity (which may be measured by pounds weight) of the pressure exerted in the moment at the impelled point; and r express the pressure exerted at the working point by the resistance opposed by the work that is then performing. This may arise from the weight of a body to be raised, from the cohesion of timber to be sawed, &c. Any of these resistances may also be measured by pounds weight; because we know, that a certain number of pounds hung on the saw of a saw mill, will just overcome this cohesion, or overcome it with any degree of superiority. Therefore the impelling power p, and the resistance r, however differing in kind, may be compared as mere pressures.

Let x represent the quantity of inert matter which must be urged by the impelling power p, with the same velocity as the impelled point, in order that this pressure p may really continue to be exerted on that point. Thus, if the impelling power is a quantity of water in the bucket of an overshot wheel, acting by its weight, this weight cannot impel the wheel except by impelling the water. In this way, x may be considered as representing the inertia of the impelling power, while p represents its pressure on the machine. In like manner, let y represent the quantity of external inert matter which is really moved with the velocity of the working point in the execution of the task performed by the machine.

Whatever be the momentum of the inertia of the machine, we can always ascertain what quantity of matter, attached to the impelled point, or the working point of the wheel and axle, will require the same force to give the wheel the same angular motion; that is, which shall have the same momentum of inertia. Let the quantity a, attached to the working point, give this momentum of inertia $a n^2$.

Lastly, supposing that the wheel and axle have no friction, let f be such a resistance, that if applied to the working point, it shall give the same obstruction as the friction of the machine, or require the same force at the impelled point to overcome it.

These

13 Angular motion of the machine.

These things being thus established, the angular velocity of the wheel and axle, that is, the number of turns, or the portion of a turn, which it will make in a given time, will be proportional to the fraction $\frac{pm - \overline{r+f}n}{xm^2 + \overline{a+y}n^2}$. (I.)—See ROTATION, n° 64, &c. *Encycl.*

Since the whole turns together, the velocities of the different points are as their distances from the axis, and may be expressed by multiplying the common angular velocity by these distances. Therefore the above formula, multiplied by m or n, will give the velocity of the impelled or of the working point. Therefore,

14 Velocity of the impelled point.

$$\text{Velocity of impelled point} = \frac{pm^2 - \overline{r+f}mn}{xm^2 + \overline{a+y}n^2}. \text{ (II.)}$$

15 Velocity of the working point.

$$\text{Velocity of working point} = \frac{pmn - \overline{r+f}n^2}{xm^2 + \overline{a+y}n^2}. \text{ (III.)}$$

In order to obtain a clear conception of these velocities, we must compare them with motions with which we are well acquainted. The proposition being universally true, we may take a case where gravity is the sole power and resistance; where, for example, p and r are the weights of the water in the bucket of a wheel, and in the tub that is raised by it. In this case, $p = x$, and $r = y$. We may also, for greater simplicity, suppose the machine without inertia and friction. The velocity of p is now $\frac{pm^2 - rmn}{pm^2 + rn^2}$.

16 Absolute measure of them.

Let g be the velocity which gravity generates in a second. Then it will generate the velocity $g\dot{t}$ in the moment $\dot{t}$. Let $\dot{v}$ be the velocity generated during this moment in p, connected as it is with the wheel and axle, and with r. This connection produces a change of condition $= g\dot{t} - \dot{v}$. For, had it fallen freely, it would have acquired the velocity $g\dot{t}$, whereas it only acquires the velocity $\dot{v}$. In like manner, had r fallen freely, it would have acquired the velocity $g\dot{t}$. But, instead of this, it is raised with the velocity $\frac{n}{m}\dot{v}$. The change on it is therefore $= g\dot{t} + \frac{n}{m}\dot{v}$. These changes of mechanical condition arise from their connection with the corporeal machine Their pressures on it bring into action its connecting forces, and each of the two external forces is in immediate equilibrium with the force exerted by the other. The force excited at the impelled point, by r acting at the working point, may be called the momentum or energy of r. These energies are precisely competent to the production of the changes which they really produce, and must therefore be conceived as having the same proportions. They are therefore equal and opposite, by the general laws *observed* in all actions of tangible matter; that is, they are such as balance each other. Thus, and only thus, the remaining motions are what we observe them to be.

$$\text{That is, } p \times \overline{g\dot{t} - \dot{v}} \times m = r \times \overline{g\dot{t} + \frac{n}{m}\dot{v}} \times n$$

$$\text{Or } pmg\dot{t} - pm\dot{v} = rng\dot{t} + r\frac{n^2}{m}\dot{v}$$

$$\text{Or } pm^2g\dot{t} - pm^2\dot{v} = rmng\dot{t} + rn^2\dot{v}$$

$$\text{Or } \overline{pm^2 - rmn} \times g\dot{t} = \overline{pm^2 + rn^2} \times \dot{v}$$

That is, $pm^2 + rn^2 : pm^2 - rmn = g\dot{t} : \dot{v}$

That is, *the denominator of the fraction, expressing the velocity of the impelled point, is to the numerator as the velocity which a heavy body would acquire in the moment* $\dot{t}$, *by falling freely, is to the velocity which the impelled point acquires in that moment.* The same thing is true of the velocity of the working point.

This reasoning suffers no change from the more complicated nature of the general proposition. Here the impelling power is still p, but the matter to be accelerated by it at the working point is $a + y$, while its reaction, diminishing the impelling power, is only r. We have only to consider, in this case, the velocity with which $a + y$ would fall freely when impelled, not by $a + y$, but only by r. The result would be the same; $g\dot{t}$ would still be to $\dot{v}$ as the denominator of the same fraction to its numerator.

Thus have we discovered the momentary acceleration of our machine. It is evident, that if the pressures p and r, and the friction and inertia of the machine, and the external matter, continue the same, the acceleration will continue the same; the motion of rotation will be uniformly accelerated, and $pm^2 + \overline{a+y}n^2$ will be to $pm^2 - \overline{r+f}mn$ as the space s, through which a heavy body would fall in any given time t, is to the space through which the impelled point will really have moved in the same time. In like manner, the space through which the working point moves in the same time is $= \frac{pmn - \overline{r+f}n^2}{pm^2 + \overline{a+y}n^2}s$.

Thus are the motions of the working machine determined. We may illustrate it by a very simple example. Suppose a weight p of five pounds, descending from a pulley, and dragging up another weight r of three pounds on the other side. m and n are equal, and each may be called 1. The formula becomes $\frac{p-r}{p+r}s$, or $\frac{5-3}{5+3}s$, or $\frac{2}{8}, = \frac{1}{4}s$. Therefore, in a second, the weight p will descend $\frac{1}{4}$th of 16 feet, or 4 feet; and will acquire the velocity of 8 feet per second.

Having obtained a knowledge of the velocity of every point of the machine, we can easily ascertain its performance. This depends on a combination of the quantity of resistance that is overcome at the working point, and the velocity with which it is overcome. Thus, in raising water, it depends on the quantity (proportional to the weight) of water in the bucket or pump, and the velocity with which it is lifted up. This will be had by multiplying the third formula by r, or by $rg\dot{t}$, or by rs. Therefore we obtain this expression, 17 Performance of the machine.

$$\text{Work done} = \frac{pmrn - \overline{r+f}rn^2}{pm^2 + \overline{a+y}n^2}g\dot{t}. \text{ (IV)}$$

Such is the general expression of the momentary performance of the machine, including every circumstance which can affect it. But a variation of those circumstances produces great changes in the results. These must be distinctly noticed.

Cor. 1. If $pmrn$ be equal to $\overline{r+f}rn^2$, there will be no work done, because the numerator of the fraction is annihilated. There is then no unbalanced force, and the

the natural power is only able to balance the pressure propagated from the working point to the impelled point.

2. In like manner, if $n = o$, no work is done altho' the machine turns round. The working point has no motion. For the same reason, if m be infinitely great, although there is a great prevalence of impelling momentum, there will not be any sensible performance during a finite time. For the velocity which p can impress is a finite quantity, and the impelled point cannot move faster than x would be moved by it if detached from the machine. Now when the infinitely remote impelled point is moved through any finite space, the motion of the working point must be infinitely less, or nothing, and no work will be done.

Remark. We see that there are two values of n, viz. o, and $m \times \frac{p}{r}$, which give no performance. But in all other proportions of m and n some work is done. Therefore, as we gradually vary the proportion of m to n, we obtain a series of values expressing the performance, which must gradually increase from nothing, and then decrease to nothing. There must therefore be some proportion of m to n, depending on the proportion of p to $\overline{r+f}$, and of n to $\overline{a+y}$, which will give the greatest possible value of the performance. And, on the other hand, if the proportion of m to n be already determined by the construction of the machine already erected, there must be some proportion of p to $\overline{r+f}$, and of n to $\overline{a+y}$, by which the greatest performance of the machine may be ensured. It is evident, that the determination of these two proportions is of the utmost importance to the improvement of machines. The well informed reader will pardon us for endeavouring to make this appear more forcibly to those who are less instructed, by means of some very simple examples of the first principle.

Suppose that we have a stream of water affording three tons per minute, and that we want to drain a pit which receives one ton per minute, and that this is to be done by a wheel and axle? We wish to know the best proportion of their diameters m and n. Let m be taken $= 6$; and suppose,

1. That $n = 5$.

Then $\frac{p m r n - r^2 n^2}{p m^2 + r n^2} = \frac{3.6.1.5 - 1.25}{3.36 + 1.36}, = \frac{65}{133}, = 0{,}4887$

2. Let n be $= 6$. The formula is $= 0{,}5$.

3. Let $n = 7$. The formula is $= 0{,}49045$. Hence we find, that the performance is greater when n is 6, than when it is either 5 or 7.

As an example of the second principle, suppose the machine a simple pulley, and let p be 10.

1. Let r be $= 3$. The formula is $\frac{10 \times 3 - 9}{10 + 3}, = \frac{21}{13}, = 1{,}6154$.

2. Let r be $= 4$. The formula is $= \frac{10 \times 4 - 16}{10 + 4}, = \frac{24}{14}, = 1{,}7143$.

3. Let r be $= 5$. The formula is $= \frac{10 \times 5 - 25}{10 + 5}, = \frac{25}{15}, = 1{,}6666$. Here it appears, that more work is done when r is 4 than when it is 5 or 3.

It must therefore be allowed to be one of the most important problems in practical mechanics to determine that construction by which a given power shall overcome a given resistance with the greatest advantage, and the proportion of work which should be given to a machine already constructed so as to gain a similar end. 18

1. The general determination of the first question has but little difficulty. We must consider n as the variable magnitude in the formula $\frac{p m r n - \overline{r+f}\, r n^2}{p m^2 + \overline{a+y}\, n^2}$, which expresses the work done; and find its value when the formula is a maximum. Taking this method, we shall find that the formula IV. is a maximum when n is

Proportion of the machine which gives the greatest work.

$$= m \frac{\sqrt{x^2 (r+f)^2 + p^2 x (a+y)} - x(r+f)}{p(a+y)}.$$

This expression of the performance, in its best state, appears pretty complex; but it becomes much more simple in all the particular applications of it, as the circumstances of the case occur in practice.

We have obtained a value of n expressed in parts of m. If we substitute this for n in the third formula, we obtain the greatest velocity with which the resistance r, connected with the inertia y, can be overcome by the power p, connected with the inertia x, by the intervention of a machine, whose momentum of inertia and friction are $a n^2$ and $f n$. This is $= \frac{r+f}{2a+y} \times \left(\sqrt{\frac{p^2\, \overline{a+y}}{\overline{r+f}^2\, x} + 1} - 1\right) g\, i$. This expresses the velocity of the working point in feet per second, and therefore the actual performance of the machine.

But the proper proportion of m to n, ascertained by this process, varies exceedingly, according to the nature both of the impelling power, and of the work to be performed by the machine.

1. It frequently happens that the work exerts no contrary strain on the machine, and consists merely in impelling a body which resists only by its inertia. This is the case in urging round a millstone or a heavy fly; in urging a body along a horizontal plane, &c. In this case r does not enter into the formula, which now becomes $m \times \frac{\sqrt{x^2 f^2 + p^2 x (a+y)} - x f}{p(a+y)}$. If the friction be insignificant we may take $n = m \sqrt{\frac{p^2 x (a+y)}{p^2 (a+y)^2}} = m \sqrt{\frac{x}{a+y}}$. The velocity of the working point is nearly $= \frac{p}{2\sqrt{x\, \overline{a+y}}}$. In this case, it will be found that the velocity acquired at the end of a given time will be nearly in the proportion of the power applied to the machine.

2. On the other hand, and more frequently, the inertia of the external matter which must be moved in performing the work need not be regarded. Thus, in the grinding of grain, sawing of timber, boring of cylinders, &c. the quantity of motion communicated to the flour, to the saw dust, &c. is too insignificant to be taken into the account. In this case, y vanishes from the formula, which becomes extremely simple when the friction and inertia of the machine are inconsiderable. We shall

ſhall not be far from the truth if we make m to n as $2r$ to p, or $n = m \times \frac{p}{2r+f}$. In this caſe, the velocity of the working point is $\frac{p^2 x}{4x(r+f) + \frac{a p^2}{4(r+f)}}$.

But it is rare that machines of this kind have a ſmall inertia. They are generally very ponderous and powerful; and the force which is neceſſary for generating even a very moderate motion in the unloaded machine (that is, unloaded with any work), bears a great proportion to the force neceſſary for overcoming the reſiſtance oppoſed by the work. The formula muſt therefore be uſed in all the terms, becauſe a is joined with y. It would have been ſimpler in this particular, had a been joined with x in the expreſſion of the angular velocity.

3. In ſome caſes we need not attend to the inertia of the power, as in the ſteam engine. In this caſe, if taken ſtrictly, n appears to have no value, becauſe x is a factor of every term of the numerator. But the formula gives this general indication, that the more inſignificant the inertia of the moving power is ſuppoſed, the larger ſhould m be in proportion to n; provided always, that the impelling power is not, by its nature, greatly diminiſhed, by giving ſo great a velocity to the impelled point. This circumſtance will be particularly conſidered afterwards.

4. If the inertia of the power and the reſiſtance be proportional to their preſſures, as when the impelling power is water lying in the buckets of an overſhot wheel, and the work is the raiſing of water, minerals, or other heavy body, acting *only* by its weight; then p and r may be ſubſtituted for x and y, and the formula expreſſing the value of n, when the performance is a maximum, becomes

$$n = m \frac{\sqrt{p^2 \times \overline{r+f}^2 + p^2 \times \overline{a+r}} - p \times \overline{r+f}}{p \times \overline{a+r}}.$$

If, in this caſe, the inertia and friction of the machine may be diſregarded, as may often be done in pulleys, we have

$$n = m\sqrt{\frac{p}{r}+1} - 1.$$

If we make m the unit of the radii, and r the unit of force, we have

$$n = \sqrt{p+1} - 1, \text{ in parts of } m = 1.$$

Or, making $p = 1$, we have $n = \sqrt{\frac{1}{r}+1} - 1$.

Theſe very ſimple expreſſions are of conſiderable uſe, even in caſes where the inertia of the machine is very conſiderable, provided that it have no reciprocating motions. A ſimple wheel and axle, or a train of good wheelwork, have very moderate friction. The general reſults, therefore, which even very unlettered readers can deduce from theſe ſimple formulæ, will give notions that are uſeful in the caſes which they cannot ſo thoroughly comprehend. Some ſervice of this kind may be derived from the following little table of the beſt proportions of m to n, correſponding to the proportions of the power furniſhed to the engineer, and the reſiſtance which muſt be overcome by it. The quantity r is always $= 10$, and $m = 1$.

p	n	p	n
1	0,0488	10	0,4142
2	0,0954	20	0,7321
3	0,1402	30	1,
4	0,1832	40	1,2362
5	0,2246	50	1,4495
6	0,2649	60	1,6457
7	0,3038	70	1,8284
8	0,3416	80	2,
9	0,3784	90	2,1623
10	0,4142	100	2,3166

This muſt ſuffice for a very general view of the firſt problem.

II. The next queſtion is not leſs momentous, namely, to determine for a machine of a given conſtruction that proportion of the reſiſtance at the working point to the impelling power which will enſure the greateſt performance of the machine; that is, the proportion of m to n being given, to find the beſt proportion of p to r. 13 Beſt proportion of the power and work.

This is a much more complicated problem than the other; for here we have to attend to the variations both of the preſſures p and r, and alſo of the external matters x and y, which are generally connected with them. It will not be ſufficient therefore to treat the queſtion by the uſual fluxionary proceſs for determining the maximum, in which r is conſidered as the only varying quantity. We muſt, in this curſory diſcuſſion, reſt ſatisfied with a comprehenſion of the circumſtances which moſt generally prevail in practice.

It muſt either happen, that when r changes, there is no change (that is, of moment) in the maſs of external matter which muſt be moved in performing the work, or that there is alſo a change in this circumſtance. If no change happens, the denominator of the fourth formula, expreſſing the performance, remains the ſame; and then the formula attains a maximum when the numerator $p r m n - \overline{r+f}\, r n^2$ is a maximum. Alſo, we may include f without complicating the proceſs, by the conſideration, that f is always in nearly the ſame ratio to r; and therefore $r+f$ may be conſidered as a certain multiple of r, ſuch as $b r$. We may therefore omit f in the fluxionary equations for obtaining the maximum, and then, in computing the performance, divide the whole by b. Thus if the whole friction be $\frac{1}{20}$th of the reſiſting preſſure r, we have $r + f = \frac{21}{20}$ of r, and $b = \frac{21}{20}$. Having aſcertained the beſt value for r, we put this in its place in the fourth formula, and take $\frac{20}{21}$ of this for the performance. This will never differ much from the truth.

This proceſs gives us $p m n = 2 n^2 r$, and $r = \frac{p m n}{2 n^2}$, $= \frac{p m}{2 n}$; and if we farther ſimplify the proceſs, by making $p = 1$, and $m = 1$, we have $r = \frac{1}{2n}$; a moſt ſimple expreſſion, directing us to make the reſiſtance one half of what would balance the impelling power by the intervention of the machine.

This will evidently apply to many very important caſes,

cafes, namely, to all thofe in which the matter put in motion by the working point is but trifling.

But it alfo happens in many important cafes, that the change is at leaft equally confiderable in the inertia of the work. In this cafe it is very difficult to obtain a general folution. But we can hardly imagine fuch a change, without fuppofing that the inertia of the work varies in the fame proportion as the preffure excited by it at the working point of the machine; for fince r continues the fame in kind, it can rarely change but by a proportional change of the matter with which it is connected. Yet fome very important cafes occur where this does not happen. Such is a machine which forces water along a long main pipe. The refiftance to motion and the quantity of water do not follow nearly the fame ratio. But in the cafes in which this ratio is obferved, we may reprefent y by any multiple br of r, which the cafe in hand gives us; b being a number, integer, or fractional. In the farther treatment of this cafe, we think it more convenient to free r from all other combinations; and inftead of fuppofing the force f (which we made equivalent with the friction of the machine) to be applied at the working point, we may apply it at the impelled point, making the effective power $q = p - f$. For the fame reafons, inftead of making the momentum of the machine's inertia $= an^2$, we may make it am^2, and make $a + n = z$. Now, fuppofing q, or $p - f$, $= 1$, and alfo $m = 1$, our formula expreffing the performance becomes $\frac{rn - r^2n^2}{z + brn^2}$. This is a maximum when $r = \frac{\sqrt{z^2 + zbn} - z}{bn^2}$.

Cor. 1. If the inertia of the work is always equal to its preffure, as when the work confifts wholly in raifing a weight, fuch as drawing water, &c. then $b = 1$, and the formula for the maximum performance becomes $r = \frac{\sqrt{zn + z^2} - z}{n^2}$.

2. If the inertia of the impelling power is alfo the fame with its preffure, and if we may neglect the inertia and friction of the machine, the formula becomes $r = \frac{\sqrt{n + 1} - 1}{n^2}$.

Example. Let the machine be a common pulley, fo that the radii m and n are equal, and therefore $n = 1$. Then, $r = \frac{\sqrt{1 + 1} - 1}{1}, = \sqrt{2} - 1, = 0{,}4142$, &c. more than $\frac{4}{10}$ths of what would balance it.

Here follows a feries of the beft values of r, correfponding to different values of n. m and p are each $= 1$. The numbers in the laft column have the fame proportion to 1 which r has to the refiftance which will balance p.

$n = \frac{1}{4}$	$r = 1{,}8885$	0,4724 to 1
$\frac{1}{3}$	1,3928	0,4639
$\frac{1}{2}$	0,8986	0,4493
1	0,4142	0,4142
2	0,1830	0,3660
3	0,1111	0,3333
4	0,0772	0,3088

From what has now been eftablifhed, we fee with fufficient evidence the importance of the higher mathematics to the fcience of mechanics. If the velocities of the impelled and working points of an engine are not properly adjufted to the preffures, the inertia, and the friction of the machine, we do not derive all the advantages which we might from our fituation. Hence alfo we learn the falfity of the maxim which has been received as well founded, that the augmentation of intenfity of any force, by applying it to the long arm of a lever, is always fully compenfated by a lofs of time; or, as it is ufually expreffed, "what we gain by a machine in force we lofe in time." If the proportion of m to n is well chofen, we fhall find that the work done, when it refifts by its inertia only, increafes nearly in the proportion of the power employed; whereas when the inertia of the work is but a fmall part of the refiftance, it increafes nearly in the duplicate ratio of the power employed.

General but erroneous maxim.

It was remarked, in the fetting out in the prefent problem, that the formulæ do not immediately exprefs the velocity of any point of the machine, but its momentary acceleration. But this is enough for our purpofe; becaufe, when the momentary acceleration is a maximum, the velocity acquired, and the fpace defcribed, in any given time, is alfo a maximum. We alfo fhewed how the real velocities, and the fpaces defcribed, may be afcertained in known meafures. We may fay in general, that if g reprefent the preffure of gravity on any mafs of matter w, then $\frac{g}{w}$ is to $\frac{pmn - \overline{r + f}\,n}{am^2 + x + yn^2}$ as 16 feet to the fpace defcribed in a fecond by the working point in a fecond, or as 32 feet per fecond is to the velocity acquired in that time.

A remark now remains to be made, which is of the greateft confequence, and gives an unexpected turn to the whole of the preceding doctrines. It appears, from all that has been faid, that the motion of a machine muft be uniformly accelerated, and that any point will defcribe fpaces proportional to the fquares of the times; for while the preffures, friction, and momentum of inertia remain the fame, the momentary acceleration muft alfo be invariable. But this feems contrary to all experience. Such machines as are properly conftructed, and work without jolts, are obferved to quicken their pace for a few feconds after ftarting; but all of them, in a very moderate time, acquire a motion that is fenfibly uniform. Is our theory erroneous, or what are the circumftances which remain to be confidered, in order to make it agree with obfervation? The fcience of machines is imperfect, till we have explained the caufes of this deviation from the theory of uniform acceleration.

Caufes why machines do not continually accelerate.

Thefe caufes are various.

1. In fome cafes, every increafe of velocity of the machine produces an increafe of friction in all its communicating parts. By thefe means, the accelerating force, which is $pm - \overline{r + f}\,n$, or $\overline{p - f}\,m - rn$, is diminifhed, and confequently the acceleration is diminifhed. But it feldom happens that friction takes away or employs the whole accelerating force. We are not yet well inftructed in the nature of friction. Moft of the kinds of friction which obtain in the communicating parts of machines, are fuch as do not fenfibly increafe by an increafe of velocity; fome of them really diminifh. Yet even the moft accurately conftructed machines, unloaded with work, attain a motion that is fenfibly uniform. If we take off the pallets from a pen-

Increafe of friction.

dulum

dulum clock, and allow it to run down amain, it accelerates for a while, but in a very moderate time it acquires an uniform motion. So does a common kitchen jack. Theſe two machines ſeem to bid the faireſt of any for an uniformly accelerated motion; for their impelling power acts with the utmoſt uniformity. There is ſomething yet unexplained in the nature of friction, which takes away ſome of this acceleration.

Reſiſ But the chief cauſe of its ceſſation in theſe two inſtances, and others *of very rapid motion*, is the reſiſtance of the air. This ariſes from the motion which is communicated to the air diſplaced by the ſwift moving parts of the machine. At firſt it is very ſmall; but it increaſes nearly in the duplicate ratio of the velocity (ſee Re-SISTANCE *of Fluids*, Encycl.) Thus r increaſes continually; and, in a certain ſtate of motion, $\overline{r+fn}$ becomes equal to $p\,m$. Whenever this happens, the accelerating power is at an end. The acceleration alſo ceaſes; and the machine is in a ſtate of dynamical equilibrium; not at reſt, but moving uniformly, and performing work.

Incre of reſiſ very imperfect known Still, however, this is not one of the general cauſes of the uniform motion attained by working engines. Rarely is the motion of their parts ſo rapid, as to occaſion any great reſiſtance from the air. But in the moſt frequent employments of machines, every increaſe of velocity is accompanied by an increaſe of reſiſtance from the work performed. This occurs at once to the imagination; and few perſons think of inquiring farther for a reaſon. But there is perhaps no part of mechanics that is more imperfectly underſtood, even in our preſent improved ſtate of mechanical ſcience. In many kinds of work, it is very difficult to ſtate what increaſe of labour is required in order to perform the work with twice or thrice the ſpeed. In grinding corn, for inſtance, we are almoſt entirely ignorant of this matter. It is very certain, that twice the force is not neceſſary for making the mill grind twice as faſt, nor even for making it grind twice as much grain equally well. It is not eaſy to bring this operation under mathematical treatment; but we have conſidered it with ſome attention, and we imagine that a very great improvement may ſtill be made in the conſtruction of griſt mills, founded on the law of variation of the reſiſtance to the operation of grinding, and a ſcientific adjuſtment of m to n, in conſequence of our knowledge of this law. We may make a ſimilar obſervation on many other kinds of work performed by machines. In none of thoſe works where the inertia of the work is inconſiderable, are we well acquainted with the real mechanical proceſs in performing it. This is the caſe in ſawing mills, boring mills, rolling mills, ſlitting mills, and many others, where the work conſiſts in overcoming the ſtrong coheſion of a ſmall quantity of matter. In ſawing timber (which is the moſt eaſily underſtood of all theſe operations), if the ſaw move with a double velocity, it is very difficult to ſay how much the actual reſiſting preſſure on the teeth of the ſaw is increaſed. Twice the number of fibres are neceſſarily torn aſunder during the ſame time, becauſe the ſame number are torn by one deſcent of the ſaw, and it makes that ſtroke in half the time. But it is very uncertain whether the reſiſtance is double on this account; becauſe if each fibre be ſuppoſed to have the ſame tenacity in both caſes, it reſiſts with this tenacity only for half the time. The parts of bodies reſiſt a ſimilar change of condition in different manners; and there is another difference in their reſiſtance of different changes—the reſiſtance of red hot iron under the roller may vary at a very different rate from that of its reſiſtance to the cutting tool. The reſiſtance of the ſpindles of a cotton mill, ariſing partly from friction, partly from the inertia of the heaped bobins, and partly from the reſiſtance of the air, is ſtill more complicated, and it may be difficult to learn its law. The only caſe in which we can judge with ſome preciſion is, when the inertia of matter, or a conſtant preſſure like that of gravity, conſtitutes the chief reſiſtance. Thus in a mill employed to raiſe water by a chain of buckets, the reſiſtance proceeds from the inertia only of the water. The buckets are moving with a certain velocity, and the loweſt of them takes hold of a quantity of water lying at reſt in the pit, and drags it into motion with its acquired velocity. The force required for generating this motion on the quieſcent water muſt be double or triple, when the velocity that muſt be given to it is ſo. This abſorbs the overplus of the impelling power, by which that power exceeds what is neceſſary for balancing the weight of the water contained in all the aſcending buckets. This is a certain determinate quantity which does not change; for in the ſame inſtant that a new bucket of water is forced into motion below, and its weight added to that of the aſcending buckets, an equal bucket is emptied of its water at top. The aſcending buckets require only to be balanced, and they then *continue* to aſcend, with any velocity already acquired. While the machine moves ſlow, the motion impreſſed on the new bucket of water is not ſufficient to abſorb all the overplus of impelling power. The quantity not abſorbed accelerates the machine, and the next bucket muſt produce more motion in the water which it takes up. This conſumes more of the overplus. This goes on till no overplus of power is left, and the machine accelerates no more. The complete performance of the machine now is, that "a certain quantity of water, formerly at reſt, is now moving with a certain velocity." Our engineers conſider it differently; "as a certain *weight* of water lifted up." But while the machine is thus moving uniformly, it is really not doing ſo much as before; that is, it is not exerting ſuch great preſſures as before the motion was rendered uniform: for at that time there was a preſſure at the working point equal to the weight of all the water in the aſcending buckets; and alſo an overplus of preſſure, by which the whole was accelerated. In the ſtate of uniform motion, the preſſure is no more than juſt balances the weight of the aſcending chain. We ſhall learn by and bye how the preſſures have been diminiſhing, although the mill has been accelerating; a thing that ſeems a paradox.

In this inſtance, then, we ſee clearly, why a machine muſt attain a uniform motion. A pumping machine gives us the ſame opportunity, but in a manner ſo different as to require explanation. The piſton may be ſuppoſed at the very ſurface of the pit water, and the impelling power may be leſs than will ſupport a column in the pipe as high as can be raiſed by the preſſure of the atmoſphere. Suppoſe the impelling power to be the water lying in the buckets of an overſhot wheel.

Let

Let this water be laid into the buckets by a very small stream. It will fill the buckets very slowly; and as this gives them a preponderance, the mill loses its balance, the wheel begins to move, and the piston to rise, and the water to follow it. The water may be delivered on the wheel drop by drop; the piston will rise by insensible degrees, always standing still again as soon as the atmospheric pressure on it just balances the water on the wheel. The water in the rising pipe is always a balance to the pressure of the atmosphere on the cistern; therefore the pressure of the atmosphere on the piston (which is the *r* in our formula) is equal to the weight of this water. Our pump-makers therefore (calling themselves engineers) say, that the weight of water in the pipe balances the water on the wheel. It does not balance it, nor is it raised by the wheel, but by the atmosphere; but it serves us at present for a measure of the power of the wheel. At last, all the buckets of the wheel are full, and the water is (for example) 25 feet high in the pipe. Now let the stream of water run its full quantity. It will only run over from bucket to bucket, and run off at the bottom of the wheel; but the mill will not move, and no work will be performed. (N. B. We are here excluding all impulse or stroke on the buckets, and supposing the water to act only by its weight.) But now let all be emptied again, and let the water be delivered on the wheel in its full quantity at the first. The wheel will immediately acquire a preponderancy, which will *greatly* exceed the first small pressure of the atmosphere on the piston. It will therefore accelerate the piston, overcoming the pressure of the air with great velocity. The piston rises fast; the water follows it, by the pressure of the atmosphere; and when it attains the former utmost height, it attains it with a considerable velocity. If allowed to run off there, it will *continue* to run off with that velocity; because there is the same quantity of water pressing round the wheel as before, and therefore enough to balance the pressure of the atmosphere on the piston. The pressure of the same atmosphere on the water in the cistern, raised the water in the pipe with this velocity; therefore it will continue to do so, and the mill will deliver water by the pump with this velocity, although there is no more pressure acting on it than before, when the water ran to waste, doing no work whatever.

This mode of action is extremely different from the former example. The mill is not acting against the inertia *y* of the water to be moved, but against the pressure *r* of the atmosphere on the piston. The pressure of the same atmosphere on the cistern is employed against the inertia of the water in the pipe; and the use of the mill is to *give occasion*, by raising the piston, to the exertion of this atmospherical pressure, which is the real raiser of the water. The maxim of construction, and the proper adjustment of *m* to *n* in this case, are different from the former; and we should run the risk of making an imperfect engine were we to confound them.

We must mention another case of a pumping mill, seemingly the same with this, but essentially different. Suppose the pipe of this pump to reach 30 feet below the surface of the pit water, and that the piston is at the very bottom of it. Suppose also, that the wheel buckets, when filled with water, only enable it to *support* 25 feet of water in the rising pipe. Let the water be delivered into the wheel drop by drop. The wheel will gradually preponderate; the piston will gradually rise, lifting the water above it, sustaining a pressure of water which gradually increases. At last, the water in the pump is 25 feet higher than that in the cistern; the wheel is full and running to waste; but no work is performed. Let all be emptied, and now let the water come to the wheel in its full stream, but without impulse. The piston will lift the water briskly, bring it to 25 feet high with a considerable velocity, and the mill will now raise it with this velocity. In this example, the mill is the immediate agent in raising the water; but, in this case also, its ultimate office is not overcoming inertia, but overcoming pressure. It was the overplus of power only that was employed in overcoming inertia, while accelerating the water in the rising pipe, in order to give it the necessary velocity for a continued discharge.

21. These and similar examples shew the great difference between the statical and dynamical equilibrium of machines, and the necessity of a scientific attention by all who wish to improve practical mechanics. Without this, and even a pretty refined attention, we cannot see the connection between a copious supply of water to the bucket wheel and a plentiful discharge by the pump. We believe, that the greatest part of those employed in erecting machines conceive it as owing to the greater weight of water impelling the wheel with greater force; but we see that there is no difference in the pressures on the mill at rest, and the mill doing its work steadily and uniformly, with any velocity, however great. Without keeping the notions of that part of the impelling power which supports distinct from that of the part which accelerates, we shall never have a clear conception of the operation of machines, or of mechanical power in general. We cannot derive all the advantages of our natural powers, without knowing how our machine employs the pressure excited by it at the working point; that is, without perceiving in what cases it is opposed to inertia, and in what to the mechanical properties of tangible matter. This only can inform us at what rate the resistance varies by a change of velocity; and when it happens that this augmentation, necessarily accompanied by an augmentation of all the frictions, and the resistance of the air, is in equilibrio with the whole of the impelling power, and all acceleration is at an end.

22 The chief cause is a real diminution of power.

Lastly, another chief cause of the finally uniform motion of machines is, that, in most cases, an increase of velocity produces a real diminution of impelling power. We hardly know any exception to this besides the employment of *one* descending weight as a power or first mover. Most of the powers which we employ reside in bodies external to the machine; and these bodies must be put in motion, and continued in that motion, in order to continue their pressure on the impelled point. Frequently a great part of the power is employed in giving this necessary motion to the external matter, and the remainder only is employed in pressing forward the machine. We mentioned a remarkable instance of this in the operation of thrashing. Now, the power thus employed must increase in proportion to the motion required; that is, in proportion to the velocity of the impelled

pelled point; what remains, urging forward the machine, is therefore diminished. The acceleration is therefore diminished, and may cease At *last* the actual pressure is so much diminished, that it is no more than what is necessary for overcoming the increased resistance of the work, the increased friction. The machine therefore accelerates no more, but moves uniformly.

This cause by gene- This cause of the diminution of power by an increase of velocity, obtains in all cases where the strength of animals, of springs, the force of fired gunpowder, &c. is exerted. In some cases, the visible effect is not very considerable; as in the employment of a strong spring, the force of gunpowder, and a few others. In the action of animals, this defalcation of power is very great when the velocity is considerable. Nay, even in the action of gravity, although it acts as strongly on a body in rapid motion as on one at rest, yet when gravity is not the immediate agent, but acts by the intervention of a body in which it resides, the necessity of previously moving this body frequently diminishes the acceleration which it would otherwise produce Thus, in an overshot wheel, if the water be delivered into the bucket with a velocity (estimated in the direction of the part of the wheel into which it is delivered) less than that of the rim of the wheel, it must retard the motion; for it must be immediately dragged into that motion; that is, part of the accelerating overplus, already acting on the wheel, must be employed in accelerating this new bucket of water, and this must lessen the general acceleration of the machine Hence we learn, that the water must be delivered on the wheel with a velocity that is at least not less than that of the wheel's motion.

ᵘnated impulse The case in which we see this diminution of power on machines most distinctly is, when water or wind, acting by impulse alone, is our moving power. Since the mutual impulses of bodies depend entirely on their relative motions (see Impulsion, *Suppl.*), it follows, that when the velocity of the impelled point is augmented, the impulsion, or effective pressure, must be diminished. Nay, this velocity may be so increased, that there shall be no relative motion, and therefore no impulsion. If the floats of an undershot wheel be moving with the velocity of the stream, they remain conjoined in their progress, but without any mutual action. Therefore, when an undershot wheel is set into a running water, the first impulsions are strong, and accelerate the wheel. This diminishes the next impulsion and acceleration: but the wheel is still impelled and accelerated; less and less in every succeeding moment, as it moves faster; by and bye, the acceleration becomes insensible, and the wheel appears to attain a motion which is perfectly uniform. This requires a very long time, or rather it is never attained, and we only cannot discern the very small additions which are still made to the velocity. All this happens generally after a very moderate time, by reason of various other obstructions.

Or by the force of animals. Animal action is subject to the same variation. We know, that there is a certain rate at which a horse can run, exhausting or employing his whole strength. If he be made to drag any the smallest load after him, he must employ part of his force on it, and his speed will be checked. The more he is loaded with a draught, the slower he will run, still employing all his strength. The draught may be increased till he is reduced to a trot, to a walk, nay, till he is unable to draw it. Now, just inverting this process, we see, that there is a certain strain which will sufficiently tire the horse without stirring from the spot, but which he could continue to exert for hours. This is greater than the load that he can just crawl along with, employing his strength as much as would be prudent to continue from day to day. And, in like manner, every lesser draught has a corresponding rate, at which the horse, employing his whole working strength, can continue to draw at during the working hours of a day. At setting out, he pulls harder, and accelerates it. Following his pull, he walks faster, and therefore pulls less (because we are still supposing him to employ his whole working strength). At last he attains that speed which occupies his whole strength in merely continuing the pull. Other animals act in a similar manner; and it becomes a general rule, that the pressure actually exerted on the impelled point of a machine diminishes as its velocity increases.

23 We must distinguish between the power expended and the power employed. From the concurrence of so many facts, we perceive that we must be careful to distinguish between the quantity of power expended, and the quantity that is usefully employed, which must be measured solely by the pressure exerted on the machine. When a weight of five pounds is employed to drag up a weight of three pounds by means of a thread over a pulley, it descends, with a motion uniformly accelerated, four feet in the first second. Mr Smeaton would call this an expenditure of a mechanical power 20. The weight three pounds is raised four feet. Mr Smeaton would call this a mechanical effect 12. Therefore the effect produced is not adequate to the power expended. But the fact is, that the pressure, strain, or mechanical power really exerted in this experiment, is neither five nor three pounds; the five pound weight would have fallen 16 feet, but it falls only 4. A force has therefore acted on it sufficient to make it describe 12 feet in a second, with a uniformly accelerated motion; for it has counteracted so much of its weight. The thread was strained with a force equal to $3\frac{3}{4}$ pounds, or $\frac{3}{4}$ths of 5 pounds. In like manner, the three pound weight would have fallen 16 feet; but it was raised 4 feet. Here was a change precisely equal to the other. A force of $3\frac{3}{4}$ pounds, acting on a mass whose matter is only 3, will, in a second, cause it to describe 20 feet with a uniformly accelerated motion. Now, 5×12, and 3×20, give the same product 60. And thus we see, that the quantity of motion extinguished or produced, and not the product of the weight and height, is the true unequivocal measure of mechanical power really expended, or the mechanical effect really produced; and that these two are always equal and opposite. At the same time, Mr Smeaton's theorem merits the attention of engineers; because it generally measures the opportunities that we have for procuring the exertion of power. In some sense Mr Smeaton may say, that the quantity of water multiplied by the height from which it descends in working our machines, is the measure of the power expended; because we must raise this quantity to the dam again, in order to have the same use of it. It is expended, but not employed; for the water, at leaving the wheel, is still able to do something.

It requires but little consideration to be sensible, that, 24 the

the preceding account of the cessation of accelerated motion in our principal machines, must introduce different maxims of construction from those which were expressly adapted to this acceleration; or rather, which proceeded on the erroneous supposition of the constancy of the impelling power and the resistance. The examination of this point has brought into view the fundamental principle of working machines, namely, the perfect equilibrium which takes place between the impelling power and the simultaneous resistance. It may be expressed thus:

First principle of working machines.

The force required for preserving a machine in uniform motion, with any velocity whatever, is that which is necessary for balancing the resistance then actually exerted on the working point of the machine. We saw this distinctly in the instance of the two weights acting against each other by the intervention of a thread over a fixed pulley. It is equally true of every case of acting machinery: for if the force at the impelled point be greater than what balances the resistance acting at the same point, it must accelerate that point, and therefore accelerate the whole machine; and if the impelling force be less than this, the machine must immediately retard in its motion. When the machine has once acquired this degree of motion, every part of it will continue in its present state of motion, if only the two external forces are in equilibrio, but not otherwise. But when the pressure of the external power on the impelled point balances the resistance opposed by that point, it is, in fact, maintaining the equilibrium with the external power acting at the working point; for this is the only way that external forces can be set in opposition to each other by the intervention of a body. The external forces are not in immediate equilibrio with each other, but each is in equilibrio with the force exerted by the point on which it acts. This force exerted by the point is a modification of the connecting forces of the body, all of which are brought into action by means of the actions of the external forces, and each is accompanied by a force precisely equal and opposite to it. Now, the principles of statics teach us the proportions of the external pressures which are thus set in equilibrium by the intervention of a body; and therefore teach us what proportion of power and resistance will keep a machine of a given construction in a state of uniform motion.

This proposition appears paradoxical, and contrary to common observation; for we find, that, in order to make a mill go faster, we must either diminish the resistance, or we must employ more men, or more water, or water moving with greater velocity, &c. But this arises from some of the causes already mentioned. Either the resistance of the work is greater when the machine is made to move faster, or the impulsion of the power is diminished, or both these changes obtain. Friction and resistance of air also come in for their share, &c. The actual pressure of any given quantity of the external power is diminished, and therefore more of it must be employed. When a weight is *uniformly* raised by a machine, the pressure exerted on it by the working point is precisely equal to its weight, whatever be the velocity with which it rises. But, even in this simplest case, more natural power must be expended in order to raise it faster; because either more natural power must be employed to accelerate the external matter which is to press forward the impelled point, or the relative motion of the pressing matter will be diminished.

It is well known, that, in the employment of the mechanic powers, whether in their state of greatest simplicity, or any how combined in a complicated machine, if the machine be put in motion, the velocities of the extreme points (which we have called the *impelled* and *working* points) are inversely proportional to the forces which are in equilibrio when applied to these points in the direction of their motion. This is an inductive proposition, and has been used as the foundation of systems of mechanics. It is unnecessary to take up time in proving what is so familiarly known; consequently, the products of the pressures at those points by the velocities of the motions are equal; that is, the product of the pressure actually exerted at the impelled point of a machine working uniformly, multiplied by the velocity of that point, is equal to the product of the resistance actually exerted at the working point, multiplied by the velocity of that point, that is, by the velocity with which the resistance is overcome,

$$p\,m = r\,n.$$

Now, the product of the resistance, by the velocity with which it is overcome, is evidently the measure of the performance of the machine, or the work done. The product of the actual pressure on the impelled point, by the velocity of that point, may be called the MOMENTUM OF IMPULSE.

23 Second principle. Momentum of impulse and the performance of the machine are equal.

Hence we deduce this proposition:

In all working machines which have acquired a uniform motion, the performance of the machine is equal to the momentum of impulse. (A)

N 2 This

(A) The truth of this proposition has been long perceived in every particular instance that happened to engage the attention; but we do not recollect any mechanician before Mr Euler considering it as a general truth, expressing in a few words a mechanical law. This celebrated mathematician undertook, about the year 1735 or 1736, a general and systematic view of machines, in order to found a complete theory immediately conducive to the improvement of practical mechanics. In 1743 he published the first propositions of this useful theory in the 10th volume of the *Comment. Petropolitani*, containing the excellent dynamical theorems of which we have given the substance. In the 3d volume of the *Comment. Novi Petropol.* he prosecuted the subject a little farther; and in the 8th volume, he entered on what we are now engaged in, and formally announces this fundamental proposition, calling these two products the *momentum of impulse*, and the *momentum of effect*. It is much to be regretted, that this consummate mathematician did not continue these useful labours; his ardent mind being carried away by more abstruse speculations in all the most refined departments of mathematics and philosophy. No man in Europe could have prosecuted the subject with more judgment and success.—See also *Mem. Acad. Berlin*, 1747 and 1752.

This is a proposition of the utmost importance in the science of machines, and leads to the fundamental maxim of their construction. Since the performance of a machine is equal to the momentum of impulse, it increases and diminishes along with it, and is a maximum when the momentum of impulse is a maximum; therefore the fundamental maxim in the construction of a machine is to fashion it in such a manner, that the momentum of impulse shall be a maximum, or that the product of the pressure actually exerted on the impelled point of the machine by the velocity with which it moves may be as great as possible. Then are we certain that the product of the resistance, by the velocity of the working point, is as great as possible, provided that we take care that none of the impulse be needlessly wasted by the way by injudicious communications of motion, by friction, by unbalanced loads, and by reciprocal motions, which irrecoverably waste the impelling power. This maxim holds good, whether the resistance remains constantly the same, or varies by any law whatever.

26 Important considerations for practice.

But much remains to be done for the improvement of mechanical science before we can avail ourselves of this maxim, and apply it with success. The chief thing, and to this we should give the most unremitting attention, is, to learn the changes which obtain in the actual pressure exerted by those natural powers which we can command; the changes of actual pressure produced by a change of the velocity of the impelled point of the machine. These depend on the specific natures of those powers, and are different in almost every different case. Nothing will more contribute to the improvement of practical mechanics than a series of experiments, well contrived, and accurately made, for discovering those laws of variation, in the cases of those powers which are most frequently employed. Such experiments, however, would be costly, beyond the abilities of an individual; therefore, it were greatly to be wished that public aid were given to some persons of skill in the science to institute a regular train of experiments of this kind. An experimental machine might be constructed, to be wrought either by men or by cattle. This should be loaded with some kind of work which can be very accurately measured, and the load varied at pleasure. When loaded to a certain degree, the men or cattle should be made to work at the rate which they can continue from day to day. The number of turns made in an hour, multiplied by the load, will give the performance corresponding to the velocities; and thus will be discovered the most advantageous rate of motion. The same machine should also be fitted for grinding, for sawing, boring, &c. and similar experiments will discover the relation between the velocities with which these operations are performed, and the resistances which they exert. The laws of friction may be investigated by the same machine. It should also be fitted with a walking wheel, and the trial should be made of the slope and the velocity of walking which gives the greatest momentum of impulse. It is not unreasonable to expect great advantages from such a train of experiments.

27 A substitute for them.

Till this be done, we must content ourselves with establishing the above, in the most general terms, applicable to any case in which the law of the variation of force may hereafter be discovered.

There is a certain velocity of the impelled point of a machine which puts an end to the action of the moving power. Thus, if the floats of an undershot wheel be moving with the velocity of the stream, no impulse is made on them. If the arm of a gin or capstan be moving with that velocity with which a horse or a man can just move, so as to continue at that speed from day to day, employing all his working strength, but not fatiguing himself; in this state of motion, the animal can exert no pressure on the machine. This may be called the EXTINGUISHING VELOCITY, and we may express it by the symbol e. Let f be that degree of force or pressure which the animal can exert at a dead pull or thrust, as it is called. We do not mean the utmost strain of which the animal is capable, but that which it can continue unremittingly during the working hours of a day, fully employing, but not fatiguing itself. And let p be the pressure which it actually exerts on the impelled point of a machine, moving with the velocity m. Let $e-m$ be called the RELATIVE VELOCITY, and let it be expressed by v. And let it be supposed, that it has been discovered, by any means whatever, that the actual pressure varies in the proportion of v^q, or $\overline{e-m}^q$. This supposition gives us $e^q : v^q = f : p$, and $p = f \times \frac{v^q}{e^q}$. For the machine must be at rest, in order that the agent may be able to exert the force f on its impelled point. But when the machine is at rest, what we have named the relative velocity is e, the whole of the extinguishing velocity.

The momentum of impulse is $p\,m$, that is $\frac{v^q}{e^q} f\,m$, or $f \times \frac{v^q}{e^q} \times \overline{e-v}$ (because $m = e-v$). Therefore $f \times \frac{v^q}{e^q} \times \overline{e-v}$ must be made a maximum. But f and e^q are two quantities which suffer no change. Therefore the momentum of impulse will be a maximum when $v^q \times \overline{e-v}$ is a maximum. Now $v^q \times \overline{e-v} = v^q e - v^q v, = v^q e - v^{q+1}$. The fluxion of this is $q\,e\,v^{q-1}\dot{v} - \overline{q+1}\,v^q\dot{v}$. This being supposed $= 0$, we have the equation

$$q\,e\,v^{q-1} = \overline{q+1}\,v^q$$

$$\text{And } q\,e = \overline{q+1}\,v$$

$$\text{Therefore } v = \frac{q\,e}{q+1}$$

And m, which is $= e-v$, becomes $\frac{e}{q+1}$. Therefore we must order matters so, that the velocity of the impelled point of the machine may be $= \frac{e}{q+1}$. Now p is $= f\frac{v^q}{e^q}$, and therefore $= f \times \frac{q^q}{\overline{q+1}^q}$. And $p\,m$, $= f\frac{q^q}{\overline{q+1}^q}m, = f\frac{q^q}{\overline{q+1}^q} \times \frac{e}{q+1}, = f \times \frac{q^q e}{\overline{q+1}^{q+1}} =$ the momentum of impulse, and therefore $=$ the momentum of effect, or the performance of the machine, when in its best state.

Thus may the maxim of construction be said to be brought to a state of great simplicity, and of most easy recollection. A particular case of this maxim has been long known, having been pointed out by Mr Parent. Since the action of bodies depends on their relative velocity,

28 Example in undershot mills by Mr Parent.

locity, the impulse of fluids must be as the square of the relative velocity. From which Mr Parent deduced, that the most advantageous velocity of the floats of an undershot wheel is one third of that of the stream. This maxim is evidently included in our general proposition; for in this case, the index q of that function of the relative velocity v, which is proportional to the impulse, is $= 2$. Therefore we have the maximum when $v = \frac{2e}{2+1}, = \frac{2}{3}e$, and $m = \frac{1}{3}e$. e, the extinguishing velocity, is evidently the velocity of the stream. Our proposition also gives us the precise value of the performance. The impulse of the stream on the float at rest being supposed $= f$, its impulse on the float moving with the velocity $\frac{2}{3}e$ must be $= \frac{4}{9}f$. This is the measure of the actual pressure p. This being multiplied by m, or by $\frac{1}{3}e$, gives $\frac{4}{27}f$. Now f is considered as equal to the weight of a column of water, having the surface of the floatboard for its base, and the depth of the sluice under the surface of the reservoir (or, more accurately, the fall required for generating the velocity of the stream) for its height. Hence it has been concluded, that the utmost performance of an undershot wheel is to raise $\frac{4}{27}$ of the water which impels it, to the height from which it falls. But this is not found very agreeable to observation. Friction, and many imperfections of execution in the delivery of the water, the direction of its impulse, &c. may be expected to make a defalcation from this theoretical performance. But the actual performance, even of mills of acknowledged imperfection, considerably exceeds this, and sometimes is found nearly double of this quantity. The truth is, that the particular fact from which Mr Parent first deduced this maxim (namely, the performance of what is called *Parent's* or *Dr Barker's mill*), is, perhaps of all that could have been selected, the least calculated for being the foundation of a general rule, being of a nature so abstruse, that the first mathematicians of Europe are to this day doubtful whether they have a just conception of its principles. Mr Smeaton's experiments shew very distinctly, that the maximum of performance of an undershot wheel corresponds to a velocity considerably greater than one-third of the stream, and approaches nearly to one-half; and he assigns some reasons for this which seem well founded. But, independent of this, the performance of Mr Smeaton's model was much greater than what corresponds with the velocity by the above mentioned estimation of f. The theory of the impulsion of fluids is extremely imperfect; and Daniel Bernoulli shews, from very unquestionable principles, that the impulse of a narrow vein of fluid on an extended surface is double of what was generally supposed; and his conclusions are abundantly confirmed by the experiments adduced by him.

Not accurate.

29 It is by no means pretended, that the maxim of construction is reduced to the great simplicity enounced in the proposition now under consideration. We only supposed, that a case had been observed where the pressure exerted by some natural agent did follow the proportions of v^q. This being admitted, the proposition is strictly true. But we do not know any such case; yet is the proposition of considerable use: for we can affirm, on the authority of our own observations, that the action both of men and of draught horses does not deviate very far from the proportions of v^2. The observations were made on men and horses tracking a lighter along a canal, and working several days together, without having any knowledge of the purpose of the observations. The force exerted was first measured by the curvature and weight of the track rope, and afterwards by a spring steelyard. This was multiplied by the number of yards per hour, and the product considered as the momentum. We found the action of men to be very nearly as $\overline{e - m}^2$. The action of horses, loaded so as not to be able to trot, was nearly as $\overline{e - m}^{1,7}$.

...is subject... useful, even where it... not altogether exact.

The practitioner can easily avail himself of the maxim, although the function q should never be reduced to any algebraic form. He has only to institute a train of experiments on the natural agent, and select that velocity which gives the highest product when multiplied by its corresponding pressure.

When this selection has been made, we have two ways of giving our working machines the maximum of effect, having once ascertained the pressure f which our natural power exerts on the impelled point of the machine when it is not allowed to move. 30

Two methods of availing ourselves of this maxim.

1. When the resistance arising from the work, and from friction, is a given quantity; as when water is to be raised to a certain height by a piston of given dimensions.

Since the friction in all the communicating parts of the machine vary in the same proportion with the pressure, and since these vary in the same proportion with the resistance, the sum of the resistance and friction may be represented by $b\,r$, b being an abstract number. Let n be the undetermined velocity of the working point; or let $m : n$ be the proportion of velocities at the impelled and working points. Then, because the pressures at these points balance each other, in the case of uniform motion, they are inversely as the velocities at those points. Therefore we must make $b\,r : p = m : n$, and $n = \frac{p\,m}{b\,r}, = \frac{\frac{q^q}{\overline{q+1}^q} f m}{b\,r}, = m \frac{q^q f}{\overline{q+1}^q\, b\,r}$, or $m : n = \overline{q+1}^q \times b\,r : q^q f$.

2. On the other hand, when $m : n$ is already given, by the construction of the machine, but $b\,r$ is susceptible of variation, we must load the machine with more and more work, till we have reduced the velocity of its impelled point to $\frac{e}{q+1}$.

In either case, the performance is expressed by what expresses $p\,m$, that is, by $f e \times \frac{q^q}{\overline{q+1}^{q+1}}$. But the useful performance, which is really the work done, will be had by dividing the value now obtained by the number b, which expresses the sum of the resistance overcome by the working point and the friction of the machine.

What has been now delivered contains, we imagine, the chief principles of the theory of machines, and points out the way in which we must proceed in applying them to every case. The reader, we hope, sees clearly the imperfection of a considera-

Recapitulation.

tion

tion of machines which proceeds no farther than the statement of the proportions of the simultaneous pressures which are excited in all the parts of the machine by the application of the external forces, which we are accustomed to call the *power* and the *weight*. Unless we take also into consideration, the immediate effect of mechanical force applied to body, and combine this with all the pressures which statical principles have enabled us to ascertain, and by this combination be able to say what portion of unbalanced force there is acting at one and all of the pressing points of the machine, and what will be the motion of *every part* of it in consequence of this overplus, we have acquired no knowledge that can be of service to us. We have been contemplating, not a working machine, but a sort of balance. But, by reasoning about these unbalanced forces in the same simple manner as about the fall of heavy bodies, we were able to discover the momentary accelerations of every part, and the sensible motion which it would acquire in any assigned time, if all the circumstances remain the same. We found that the results, although deduced from unquestionable principles, were quite unlike the observed motions of most working machines. Proceeding still on the same principles, we considered this deviation as the indication, and the precise measure, of something which we had not yet attended to, but which the deviation brought into view, and enabled us to ascertain with accuracy. These are the changes which happen in the exertions of our actuating powers by the velocity with which we find it convenient to make them act. Thus we learn more of the nature of those powers; and we found it necessary to distinguish carefully between the apparent magnitude of our actuating power and its real exertion in doing our work. This consideration led us to a fundamental proposition concerning all working machines when they have attained an uniform motion; namely, that the power and resistance then really exerted on the machine precisely balance each other, and that the machine is precisely in the condition of a steelyard loaded with its balanced weights, and moved round its axis by some external force distinct from the power and the weight. We found that this force is the previous overplus of impelling power, before the machine had acquired the uniform motion; and on this occasion we learned to estimate the effect produced, by the momentum (depending on the form of the machine) of the quantity of motion produced in the whole assemblage of power, resistance, and machine.

31 Theory of machines still intricate, especially of such as reciprocate.

The theory of machines seemed to be now brought back to that simplicity of equilibrium which we had said was so imperfect a foundation for a theory; but in the availing ourselves of the maxim founded on this general proposition, we saw that the equilibrium is of a very different kind from a quiescent equilibrium. It necessarily involves in it the knowledge of the momentary accelerations and their momenta; without which we should not perceive that one state of motion is more advantageous than another, because all give us the same proportion of forces in equilibrio.

But this is not the only use of the previous knowledge of the momentary accelerations of machines; there are many cases where the machine works in this very state. Many machines accelerate throughout while performing their work ... their efficacy depend-ently on the final acceleration. Of this kind is the coining press, the great forge or tilt mill, and some other capital engines. The steam engine, and the common pump, are necessarily of this class, although their efficacy is not estimated by their final acceleration. A great number of engines have reciprocating motions in different subordinate parts. The theory of all such engines requires for its perfection an accurate knowledge of the momentary accelerations; and we must use the formulæ contained in the first part of this article.

32 Working and returning strokes.

Still, however, the application of this knowledge has many difficulties, which make a *good* theory of such machines a much more intricate and complicated matter than we have yet led the reader to suppose. In most of these engines, the whole motion may be divided into two parts. One may be called the WORKING STROKE, and the other in which the working points are brought back to a situation which fits them for acting again, may be called the RETURNING STROKE. This return must be effected either by means of some immediate application of the actuating power, or by some other force, which is counteracted during the working stroke, and must be considered as making part of the resistance. In the steam engine, it is generally done by a counterpoise on the outer end of the great working beam. This must be accounted a part of the resistance, for it must be raised again; and the proportions of the machine for attaining the maximum must be computed accordingly. The quantity of this counterpoise must be adjusted by other considerations. It must be such, that the descent of the pump rods in the pit may *just employ the whole time* that is necessary for filling the cylinder with steam. If they descend more briskly (which an unskilful engineer likes to see), this must be done by means of a greater counterpoise, and this employs more power to raise it again. Desaguliers describes a very excellent machine for raising water in a bucket, by a man's stepping into an opposite bucket, and descending by his preponderancy. When he comes to the bottom, he steps out, goes up a stair, and finds the bucket returned and ready to receive him again. This machine is extremely simple, and perhaps the best that can be contrived; and yet it is one of the most likely to be a very bad one. The bucket into which the man steps must be brought up to its place again by a preponderancy in the machine when unloaded. It may be returned sooner or later. It should arrive precisely at the same time with the man. If sooner, it is of no use, and wastes power in raising a counterpoise which is needlessly heavy; if later, time is lost: Therefore, the perfection of this very simple machine requires the judicious combination of two maximums, each of which varies in a ratio compounded of two other ratios. Suppose the man to employ a minute to go up stairs 50 feet, which is very nearly what he can do from day to day as his only work, and suppose him to weigh 150 pounds, and that he acts by means of a simple pulley—the maximum for a lever of equal arms would require him to raise about 60 pounds of water. But when all the other circumstances are calculated, it will be found that he must raise 138 pounds (neglecting the inertia of the machine). He should raise 547 pounds 10 feet in a minute; and this is nearly the most exact valuation of a man's work.

There is the same necessity of attending to a variety

of circumſtances in all machines which reciprocate in the whole or any conſiderable part of their motion. The force employed for bringing the machine into another working poſition, muſt be regulated by the time neceſſary for obtaining a new ſupply of power; and then the proportion of x to n muſt be ſo adjuſted, that the work performed, divided by the *whole* time of the working and returning ſtrokes, may give the greateſt quotient. It is ſtill a difficult thing, therefore, to conſtruct a machine in the moſt perfect manner, or even to ſay what will be the performance of a machine already conſtructed; yet we ſee that every circumſtance is ſuſceptible of accurate computation.

With reſpect to machines which acquire a ſort of uniform motion in general, although ſubject to partial reciprocations, as in a pumping, ſtamping, forging engine, it is alſo difficult to aſſign the rate even of this general uniform motion. We may, however, ſay, that it will not be greater than if it were uniform throughout. Were it entirely free from friction, it would be exactly the ſame as if uniform; becauſe the accelerations during the advantageous ſituations of the impelling power would compenſate the retardations. But friction diminiſhes the accelarations, without diminiſhing the retardations.

We may conclude this article with ſome obſervations tending to the general improvement of machines.

33 Uniformity of motion [illegible] of great advantage. Nothing contributes more to the per[illegible] a ma-[illegible] tion waſtes ſome of the impelling power; and it is only the greateſt of the varying velocities which is equal to that which the machine would acquire if moving uniformly throughout; for, while the motion accelerates, the impelling force is greater than what balances the reſiſtance then actually oppoſed to it, and the velocity is leſs than what the machine would acquire if moving uniformly: and when the machine attains its greateſt velocity, it attains it becauſe the power is then not acting againſt the whole reſiſtance. In both of theſe ſituations, therefore, the performance of the machine is leſs than if the power and reſiſtance were exactly balanced; in which caſe it would move uniformly.

34 How to attain this. Every attention ſhould therefore be given to this, and we ſhould endeavour to remove all cauſe of irregularity. The communications of motion ſhould be ſo contrived, that if the impelled point be moving uniformly, by the uniform preſſure of the power, the working point ſhall alſo be moving uniformly. Then we may generally be certain, that the maſſy parts of the machine will be moving uniformly. When this is not done through the whole machine, there are continual returns of ſtrains and jolts; the inertia of the different parts acting in oppoſite directions. Although the whole momenta may always balance each other, yet the general motion is hobbling, and the points of ſupport are ſtrained. A great engine ſo conſtructed, commonly cauſes the building to tremble; but when uniform motion pervades the whole machine, the inertia of each part tends to preſerve this uniformity, and all goes ſmoothly. It is alſo deſerving of remark, that when the communications are ſo con[illegible]d that the motion of one part produces uniform motion on the next, the preſſures at the communicating points remain conſtant or invariable. Now the accompliſhing of this is always within the reach of mechanics.

35 Beſt forms for the teeth of wheels Plate XXXIII. fig. 1. One of the moſt uſual communications in machinery is by means of toothed wheels acting on each other. It is of importance to have the teeth ſo formed, that the preſſure by which one of them A urges the other B round its axis ſhall be conſtantly the ſame. It can eaſily be demonſtrated, that when this is the caſe, the uniform angular motion of the one will produce a uniform angular motion of the other; or, if the motions are thus uniform, the preſſures are invariable. This is accompliſhed on this principle, that the mutual actions of ſolid bodies on each other in the way of preſſure are perpendicular to the touching ſurfaces. Therefore let the tooth a preſs on the tooth b in the point C; and draw the line FCDE perpendicular to the touching ſurfaces in the point C. Draw AF, BE perpendicular to FE, and let FE cut the line AB in D. It is plain, from the common principles of mechanics, that if the line FE, drawn in the manner now deſcribed, always paſs through the ſame point D, whatever may be the ſituation of the acting teeth, the mutual action of the wheels will always be the ſame. It will be the ſame as if the arm AD acted on the arm BD. In the treatiſes on the conſtruction of mills, and other works of this kind, are many inſtructions for the formation of the teeth of wheels; and almoſt every noted millwright has his own noſtrums. Moſt of them are egregiouſly faulty in reſpect of mechanical principle. Indeed they are little elſe than inſtructions how to make the teeth clear each other without ſticking. Mr de la Hire firſt pointed out the above mentioned principle, and juſtly condemned the common practice of making the ſmall wheel or pinion in the form of a lantern (whence it alſo took its name), conſiſting of two round diſks, having a number of cylindrical ſpokes (fig. 2.) The ſlighteſt inſpection of this conſtruction ſhews, that, in the different ſituations of the working teeth, the line FCE continually changes its interſection with AB. If the wheel B be very ſmall in compariſon of the other, and if the teeth of A take deep hold of the cylindrical pins of B, the line of action EF is ſometimes ſo diſadvantageouſly placed, that the preſſure of the one wheel has ſcarcely any tendency at all to turn the other. Mr de la Hire, or Dr Hooke, was, we think, the firſt who inveſtigated the form of a tooth which procured this conſtant action between the wheels; and in a very ingenious diſſertation, publiſhed among the Memoirs of the Academy of Sciences at Paris 1668, the former of theſe gentlemen ſhews, that this will be enſured by forming the teeth into epicycloids. Epicycloid teeth by De la Hire. Mr Camus of the ſame Academy has publiſhed an elaborate diſſertation on the ſame ſubject, in which he proſecutes the principle of Mr de la Hire, and applies it to all the variety of caſes which can occur in practice. There is no doubt as to the goodneſs of the principle; and it has another excellent property, "that the mutual action of the teeth is abſolutely without any friction." The one tooth only applies itſelf to the other, and rolls on it, but does not ſlide or rub in the ſmalleſt degree. This makes them laſt long, or rather does not allow them to wear in the leaſt. But the conſtruction is ſubject to a limitation which muſt not be neglected. The teeth muſt be ſo made, that the curved part of the tooth b is acted on by a flat part of the tooth a till it comes to the line AB in the courſe of its action; after which

which the curved part of a acts on a flat part of b; or the whole action of a on b is either completed, or only begins at the line AB, joining the centres of the wheels.

36
A better form.

Another form of the teeth secures the perfect uniformity of action without this limitation, which requires very nice execution. Let the teeth of each wheel be formed by evolving its circumference; that is, let the acting face GCH of the tooth a have the form of the curve traced by the extremity of the thread FC, unlapped from the circumference. In like manner, let the acting face of the tooth b be formed by unlapping a thread from its circumference. It is evident, that the line FCE, which is drawn perpendicularly to the touching surfaces in the point C, is just the direction or position of the evolving threads by which the two acting faces are formed. This line must therefore be the common tangent to the two circles or circumferences of the wheels, and will therefore always cut the line AB in the same point D. This form allows the teeth to act on each other through the whole extent of the line FCE, and therefore will admit of several teeth to be acting at the same time (twice the number that can be admitted in Mr de la Hire's method). This, by dividing the pressure among several teeth, diminishes its quantity on any one of them, and therefore diminishes the dents or impressions which they unavoidably make on each other. It is not altogether free from sliding and friction, but the whole of it can hardly be said to be sensible. The whole slide of a tooth three inches long, belonging to a wheel of ten feet diameter, acting on a tooth of a wheel of two feet diameter, does not amount to $\frac{1}{20}$th of an inch, a quantity altogether insignificant.

In the formation of the teeth of wheels, a small deviation from these perfect forms is not perhaps of very great importance, except in cases where a very large wheel drives a very small one (a thing which a good engineer will always avoid). As the construction, however, is exceedingly easy, it would be unpardonable to omit it. Well formed teeth, and a great number of them acting at once, make the communication of motion extremely smooth and uniform. The machine works without noise, and the teeth last a very long time without sensibly changing their shape. But there are cases, such as the pallets of clocks and watches, where the utmost accuracy of form is of the greatest importance for the perfection of the work.

37
Maxim for the construction of stampers, &c.

When heavy stampers are to be raised, in order to drop on the matters to be pounded, the wipers by which they are lifted should be made of such a form, that the stamper may be raised by a uniform pressure, or with a motion almost perfectly uniform. If this is not attended to, and the wiper is only a pin sticking out from the axis, the stamper is forced into motion at once. This occasions violent jolts to the machine, and great strains on its moving parts and their points of support; whereas when they are gradually lifted, the inequality of desultory motion is never felt at the impelled point of the machine. We have seen pistons moved by means of a double rack on the piston rod. A half wheel takes hold of one rack, and raises it to the required height. The moment the half wheel has quitted that side of the rack, it lays hold of the other side, and forces the piston down again. This is proposed as a great improvement; correcting the unequable motion of the piston moved in the common way by a crank. But it is far inferior to the crank motion. It occasions such abrupt changes of motion, that the machine is shaken by jolts. Indeed if the movement were accurately executed, the machine would be shaken to pieces, if the parts did not give way by bending and yielding. Accordingly, we have always observed that this motion soon failed, and was changed for one that was more smooth. A judicious engineer will avoid all such sudden changes of motion, especially in any ponderous part of a machine.

When several stampers, pistons, or other reciprocal movers, are to be raised and depressed, common sense teaches us to distribute their times of action in a uniform manner, so that the machine may always be equally loaded with work. When this is done, and the observations in the preceding paragraph attended to, the machine may be made to move almost as smoothly as if there were no reciprocations in it. Nothing shews the ingenuity of the author more than the artful yet simple and effectual contrivances for obviating those difficulties that unavoidably arise from the very nature of the work that must be performed by the machine, and of the power employed. The inventive genius and found judgment of Watt and Boulton are as perceptible to a skilled observer in these subordinate parts of some of their great engines, as in the original discovery on which their patent is founded. In some of those engines the mass of dead matter which must be put into motion, and this motion destroyed and again restored in every stroke, is enormous, amounting to above an hundred tons. The ingenious authors have even contrived to draw some advantages from it, by allowing a great want of equilibrium in certain positions; and this has been condemned as a blunder by engineers who did not see the use made of it.

There is also great room for ingenuity and good choice in the management of the moving power, when it is such as cannot immediately produce the kind of motion required for effecting the purpose. We mentioned the conversion of the continued rotation of an axis into the reciprocating motion of a piston, and the improvement which was thought to have been made on the common and obvious contrivance of a crank, by substituting a double rack on the piston rod, and the inconvenience arising from the jolts occasioned by this change. We have seen a great forge, where the engineer, in order to avoid the same inconvenience arising from the abrupt motion given to the great sledge hammer of seven hundred weight, resisting with a five-fold momentum, formed the wipers into spirals, which communicated motion to the hammer almost without any jolt whatever; but the result was, that the hammer rose no higher than it had been raised in contact with the wiper, and then fell on the iron bloom with very little effect. The cause of its inefficiency was not guessed at; but it was removed, and wipers of the common form were put in place of the spirals. In this operation, the rapid motion of the hammer is absolutely necessary. It is not enough to *lift* it up; it must be *tossed* up, so as to fly higher than the wiper lifts it, and to strike with great force the strong oaken spring which is placed in its way. It compresses this spring, and is reflected by it with a considerable velocity, so as to hit the iron as if it had fallen from a great height. Had

38
The unavoidable inequalities of moving power must be compensated by the construction.

it been allowed to fly to that height, it would have fallen upon the iron with ſomewhat more force (becauſe no oaken ſpring is perfectly elaſtic); but this would have required more than twice the time.

38 Great inconveniences of a reciprocating power.

In employing a power which of neceſſity reciprocates, to drive machinery which requires a continuous motion (as in applying the ſteam engine to a cotton or a griſt mill), there alſo occur great difficulties. The neceſſity of reciprocation in the firſt mover waſtes much power; becauſe the inſtrument which communicates ſuch an enormous force muſt be extremely ſtrong, and be well ſupported. The impelling power is waſted in imparting, and afterwards deſtroying, a vaſt quantity of motion in the working beam. The ſkilful engineer will attend to this, and do his utmoſt to procure the neceſſary ſtrength of this firſt mover, without making it a vaſt load of inert matter. He will alſo remark, that all the ſtrains on it, and on its ſupports, are changing their directions in every ſtroke. This requires particular attention to the manner of ſupporting it. If we obſerve the ſteam engines which have been long erected, we ſee that they have uniformly ſhaken the building to pieces. This has been owing to the ignorance or inattention of the engineer in this particular. They are much more judiciouſly erected now, experience having taught the moſt ignorant that no building can withſtand their deſultory and oppoſite jolts, and that the great movements muſt be ſupported by a framework independent of the building of maſonry which contains it (N).

The engineer will alſo remark, that when a ſingle ſtroke ſteam engine is made to turn a mill, all the communications of motion change the direction of their preſſure twice every ſtroke. During the working ſtroke of the beam, one ſide of the teeth of the intervening wheels is preſſing the machinery forward; but during the returning ſtroke, the machinery, already in motion, is dragging the beam, and the wheels are acting with the other ſide of the teeth. This occaſions a rattling at every change, and makes it proper to faſhion both ſides of the teeth with the ſame care.

It will frequently conduce to the good performance of an engine, to make the action of the reſiſting work unequable, accommodated to the inequalities of the impelling power. This will produce a more uniform motion in machines in which the momentum of inertia is inconſiderable. There are ſome beautiful ſpecimens of this kind of adjuſtment in the mechaniſm of animal bodies.

39 ure, &c. ation, le of FLY.

It is very cuſtomary to add what is called a FLY to machines. This is a heavy diſk or hoop, or other maſs of matter, *balanced on its axis*, and ſo connected with the machinery as to turn briſkly round with it. This may be done with the view of rendering the motion of the whole more regular, notwithſtanding unavoidable inequalities of the accelerating forces, or of the reſiſtances occaſioned by the work. It becomes a REGULATOR. Suppoſe the reſiſtance extremely unequal, and the impelling power perfectly conſtant; as when a bucket wheel is employed to work *one* pump. When the piſton has ended its working ſtroke, and while it is going down the barrel, the power of the wheel being ſcarcely oppoſed, it accelerates the whole machine, and the piſton arrives at the bottom of the barrel with a conſiderable velocity. But in the riſing again, the wheel is oppoſed by the column of water now preſſing on the piſton. This immediately retards the wheel; and when the piſton has reached the top of the barrel, all the acceleration is undone, and is to begin again. The motion of ſuch a machine is very hobbling: but the ſuperplus of accelerating force at the beginning of a returning ſtroke will not make ſuch a change in the motion of the machine if we connect the fly with it. For the accelerating momentum is a determinate quantity. Therefore, if the radius of the fly be great, this momentum will be attained by communicating a ſmall angular motion to the machine. The momentum of the fly is as the ſquare of its radius; therefore it reſiſts acceleration in this proportion; and although the overplus of power generates the ſame momentum of rotation in the whole machine as before, it makes but a ſmall addition to its velocity. If the diameter of the fly be doubled, the augmentation of rotation will be reduced to one-fourth. Thus, by giving a rapid motion to a ſmall quantity of matter, the great acceleration during the returning ſtroke of the piſton is prevented. This acceleration continues, however, during the whole of the returning ſtroke, and at the end of it the machine has acquired its greateſt velocity. Now the working ſtroke begins, and the overplus of power is at an end. The machine accelerates no more; but if the power is juſt in equilibrio with the reſiſtance, it keeps the velocity which it has acquired, and is ſtill more accelerated during the *next* returning ſtroke. But now, at the beginning of the ſubſequent working ſtroke, there is an overplus of reſiſtance, and a retardation begins, and continues during the whole rise of the piſton; but it is inconſiderable in compariſon of what it would have been without the fly; for the fly, retaining its acquired momentum, drags forward the reſt of the machine, aiding the impelling power of the wheel. It does this by all the communications taking into each other in the oppoſite direction. The teeth of the intervening wheels are heard to drop from their former contact on one ſide, to a contact on the other. By conſidering this proceſs with attention, we eaſily perceive that, in a few ſtrokes, the overplus of power during the returning ſtroke comes to be ſo adjuſted to the deficiency during the working ſtroke, that the accelerations and retardations exactly deſtroy each other, and every ſucceeding ſtroke is made with the ſame velocity, and an equal number of ſtrokes is made in every ſucceeding minute. Thus the machine acquires a general uniformity with periodical inequalities. It is plain, that by ſufficiently enlarging either the diameter or the weight

(N) The gudgeons of a water-wheel ſhould never reſt on the wall of the building. It ſhakes it; and if ſet up ſoon after the building has been erected, it prevents the mortar from taking firm bond; perhaps by ſhattering the calcareous cryſtals as they form. When the engineer is obliged to reſt the gudgeons in this way, they ſhould be ſupported by a block of oak laid a little hollow. This ſoftens all tremors, like the ſprings of a wheel carriage. This practice would be very ſerviceable in many other parts of the conſtruction.

weight of the fly, the irregularity of the motion may be rendered as small as we please. It is much better to enlarge the diameter. This preserves the friction more moderate, and the pivot wears less. For these reasons, a fly is in general a considerable improvement in machinery, by equalising many exertions that are naturally very irregular. Thus, a man working at a common windlass, exerts a very irregular pressure on the winch. In one of his positions in each turn he can exert a force of near 70 pounds without fatigue, but in another he cannot exert above 25; nor must he be loaded with much above this in general. But if a large fly be connected properly with the windlass, he will act with equal ease and speed against 30 pounds.

40 It is a powerful regulator.

This regulating power of the fly is without bounds, and may be used to render uniform a motion produced by the most desultory and irregular power. It is thus that the most regular motion is given to mills that are driven by a single stroke steam engine, where for two or even three seconds there is no force pressing round the mill. The communication is made through a massive fly of very great diameter, whirling with great rapidity. As soon as the impulse ceases, the fly, continuing its motion, urges round the whole machinery with almost unabated speed. At this instant all the teeth, and all the joints, between the fly and the first mover, are heard to catch in the opposite direction.

If any permanent change should happen in the impelling power, or in the resistance, the fly makes no obstacle to its producing its full effect on the machine; and it will be observed to accelerate or retard uniformly, till a new general speed is acquired exactly corresponding with this new power and resistance.

Many machines include in their construction movements which are equivalent with this intentional regulator. A flour mill, for example, cannot be better regulated than by its millstone; but in the Albion mills, a heavy fly was added with great propriety; for if the mills had been regulated by their millstones only, then at every change of stroke in the steam engine, the whole train of communications between the beam, which is the first mover, and the regulating millstone, which is the very last mover, would take in the opposite direction. Although each drop in the teeth and joints be but a trifle, the whole, added together, would make a considerable jolt. This is avoided by a regulator immediately adjoining to the beam. This continually presses the working machinery in one direction. So judiciously were the movements of that noble machine contrived, and so nicely were they executed, that not the least noise was heard, nor the slightest tremor felt in the building.

* See Pile Engine, Encycl.

Mr Valoué's beautiful pile engine employed at Westminster Bridge is another remarkable instance of the regulating power of a fly*. When the ram is dropped, and its follower disengaged immediately after it, the horses would instantly tumble down, because the load, against which they had been straining hard, is at once taken off; but the gin is connected with a very large fly, which checks any remarkable acceleration, allowing the horses to lean on it during the descent of the load; after which their draught recommences immediately. The spindles, cards, and bobbins, of a cotton mill, are also a sort of flies. Indeed all bulky machines of the rotative kind tend to preserve their motion with some degree of steadiness, and their great momentum of inertia is as useful in this respect as it is prejudicial to the acceleration or any reciprocation, when wanted.

41 A bad construction of a fly.

There is another kind of regulating fly, consisting of wings whirled briskly round till the resistance of the air prevents any great acceleration. This is a very bad one for a *working* machine, for it produces its effect by *really wasting* a part of the moving power. Frequently it employs a very great and unknown part of it, and robs the proprietor of much work. It should never be introduced into any machine employed in manufactures.

42 A conical pendulum is the most perfect regulator.

Some rare cases occur where a very different regulator is required; where a certain determined velocity is found necessary. In this case the machine is furnished, at its extreme mover, with a conical pendulum, consisting of two heavy balls hanging by rods, which move in very nice and steady joints at the top of a vertical axis. It is well known, that when this axis turns round, with an angular velocity suited to the length of those pendulums, the time of a revolution is determined. Thus, if the length of each pendulum be $39\frac{1}{4}$ inches, the axis will make a revolution in two seconds very nearly. If we attempt to force it more swiftly round, the balls will recede a little from the axis, but it employs as long time for a revolution as before; and we cannot make it turn swifter, unless the impelling power be increased beyond all probability; in which case the pendulum will fly out from the centre till the rods are horizontal, after which every increase of power will accelerate the machine very sensibly. W[illegible] this contrivance with great [illegible] gines, when they are empl[illegible] [illegible]ing machinery [illegible] manufactures which have a very [illegible]ingeable resist[illegible] and where a certain speed cannot be much departed from without great inconvenience. They have connected this recess of the balls from the axis (which gives immediate indication of an increase of power or a diminution of resistance) with the cock which admits the steam to the working cylinder. The balls flying out, cause the cock to close a little, and diminish the supply of steam. The impelling power diminishes the next moment, and the balls again approach the axis, and the rotation goes on as before, although there may have occurred a very great excess or deficiency of power. The same contrivance may be employed to raise or lower the feeding sluice of a water mill employed to drive machinery.

43 A fly sometimes collects power

A fly is sometimes employed for a very different purpose from that of a regulator of motion—it is employed as a *collector of power*. Suppose all resistance removed from the working point of a machine furnished with a very large or heavy fly immediately connected with the working point. When a small force is applied to the impelled point of this machine, motion will begin in the machine, and the fly begin to turn. Continue to press uniformly, and the machine will accelerate. This may be continued till the fly has acquired a very rapid motion. If at this moment a resisting body be applied to the working point, it will be acted on with very great force; for the fly has now accumulated in its circumference a very great momentum. If a body were exposed immediately to the action of this circumference, it would be violently struck. Much more will it be so, if the body be exposed to the action of the

working

working point, which perhaps makes one turn while the fly makes a hundred. It will exert a hundred times more force there (very nearly) than at its own circumference. All the motion which has been accumulated on the fly during the whole progress of its acceleration is exerted in an instant at the working point, multiplied by the momentum depending on the proportion of the parts of the machine. It is thus that the coining press performs its office; nay, it is thus that the blacksmith forges a bar of iron. Swinging the great sledge hammer round his head, and urging it with force the whole way, this accumulated motion is at once extinguished by impact on the iron. It is thus we drive a nail; and it is thus that by accumulating a very moderate force exerted during four or five turns of a fly, the whole of it is exerted on a punch set on a thick plate of iron, such as is employed for the boilers of steam engines. The plate is pierced as if it were a bit of cheese. This accumulating power of a fly has occasioned many who think themselves engineers to imagine, that a fly really adds power or mechanical force to an engine; and, not understanding on what its efficacy depends, they often place the fly in a situation where it only added a useless burden to the machine. It should always be made to move with rapidity. If intended for a mere regulator, it should be near the first mover. If it is intended to accumulate force in the working point, it should not be far separated from it. In a certain sense, a fly may be said to add power to a machine, because by accumulating into the exertion of one moment the exertions of many, we can sometimes overcome an obstacle that we never could have balanced by the same machine unaided by the fly.

It is this accumulation of force which gives such an appearance of power to some of our first movers. When a man is unfortunately catched by the teeth of a paltry country mill, he is crushed almost to mummy. The power of the stream is conceived to be prodigious; and yet we are certain, upon examination, that it amounts to the pressure of no more than fifty or sixty pounds. But it has been acting for some time; and there is a millstone of a ton weight whirling twice round in a second. This is the force that crushed the unfortunate man; and it required it all to do it, for the mill stopped. We saw a mill in the neighbourhood of Elbingroda in Hanover, where there was a contrivance which disengaged the millstone when any thing got entangled in the teeth of the wheels. It was tried in our sight with a head of cabbage. It crushed it indeed, but not violently, and would by no means have broken a man's arm.

44 plicity onstruc recom- ded.

It is hardly necessary to recommend simplicity in the construction of machines. This seems now sufficiently understood. Multiplicity of motions and communications increases frictions; increases the unavoidable losses by bending and yielding in every part; exposes to all the imperfections of workmanship; and has a great chance of being indistinctly conceived, and therefore constructed without science. We think the following construction of a capstan or crab a very good example of the advantages of simplicity. It is the invention of an untaught but very ingenious country tradesman.

3. EAB is the barrel of the capstan, standing vertically in a proper frame, as usual, and urged round by bars such as EF. The upper part A of the barrel is 17 inches in diameter, and the lower B is 16. C is a strong pulley 16 inches in diameter, having a hook D, which takes hold of a hawser attached to the load. The rope ACB is wound round the barrel A, passes over the pulley C, and is then wound round the barrel B in the opposite direction. No farther description is necessary, we think, to shew that, by heaving by the bar F, so as to wind more of the rope upon A, and unwind it from B, the pulley C must be brought nearer to the capstan by about three inches for each turn of the capstan; and that this simple capstan is equivalent to an ordinary capstan of the same length of bar EF, and diameter of barrel B, combined with a 16 fold tackle of pulleys; or, in short, that it is 16 times more powerful than the common capstan; free from the great loss by friction and bending of ropes, which would absorb a third of the power of a 16 fold tackle; and that whereas all other engines become weaker as they multiply the power to a greater degree (unless they are proportionally more bulky), this engine becomes really stronger in itself. Suppose we wanted to have it twice as powerful as at present; nothing is necessary but to cover the part B of the barrel with laths a quarter of an inch thick. In short, the nearer the two barrels are to equality, the more powerful does it become. We give it to the public as an excellent capstan, and as suggesting thoughts which an intelligent engineer may employ with great effect. By this contrivance, and using an iron wire instead of a catgut, we converted a common eight day clock into one which goes for two months.

45 Example of a very simple and powerful capstan.

We intended to conclude this article with some observations on the chief classes of powers which are employed to drive machinery; such as water, wind, atmospheric pressure, gunpowder, and the force of men and other animals, giving some notion of their absolute magnitudes, and the effect which may be expected from them. We should then have mentioned what has been discovered as to their variation by a variation of velocity. And we intended to conclude with an account of what knowledge has been acquired concerning friction, and the loss of power in machinery arising from this cause, and from the stiffness of ropes, and some other causes: But we have not yet been able to bring these matters into a connected form, which would suggest the methods and means of farther information thereon. We must endeavour to find another opportunity of communicating to the public what we may yet learn on those subjects.

We have now established the principles on which machines must be constructed, in order that they may produce the greatest effect; but it would be improper to dismiss the subject without stating to our readers Mr Bramah's new method of producing and applying a more considerable degree of power to all kinds of machinery requiring motion and force, than by any means at present practised for that purpose. This method, for which on the 31st of March 1796 he obtained a patent, consists in the application of water or other dense fluids to various engines, so as, in some instances, to

to cause them to act with immense force; in others, to communicate the motion and powers of one part of a machine to some other part of the same machine; and, lastly, to communicate the motion and force of one machine to another, where their local situations preclude the application of all other methods of connection.

The first and most material part of this invention will be clearly understood by an inspection of fig. 4. where "A is a cylinder of iron, or other materials, sufficiently strong, and bored perfectly smooth and cylindrical; into which is fitted the piston B, which must be made perfectly water-tight, by leather or other materials, as used in pump-making. The bottom of the cylinder must also be made sufficiently strong with the other part of the surface, to be capable of resisting the greatest force or strain that may at any time be required. In the bottom of the cylinder is inserted the end of the tube C; the aperture of which communicates with the inside of the cylinder, under the piston B, where it is shut with the small valve D, the same as the suction-pipe of a common pump. The other end of the tube C communicates with the small forcing pump or injector E, by means of which water or other dense fluids can be forced or injected into the cylinder A, under the piston B. Now, suppose the diameter of the cylinder A to be 12 inches, and the diameter of the piston of the small pump or injector E only one quarter of an inch, the proportion between the two surfaces or ends of the said pistons will be as 1 to 2304; and supposing the intermediate space between them to be filled with water or other dense fluid capable of sufficient resistance, the force of one piston will act on the other just in the above proportion, viz. as 1 is to 2304. Suppose the small piston in the injector to be forced down when in the act of pumping or injecting water into the cylinder A, with the power of 20 cwt. which could easily be done by the lever H; the piston B would then be moved up with a force equal to 20 cwt. multiplied by 2304. Thus is constructed a hydro-mechanical engine, whereby a weight amounting to 2304 tons can be raised by a simple lever, through equal space, in much less time than could be done by any apparatus constructed on the known principles of mechanics; and it may be proper to observe, that the effect of all other mechanical combinations is counteracted by an accumulated complication of parts, which renders them incapable of being usefully extended beyond a certain degree; but in machines acted upon or constructed on this principle, every difficulty of this kind is obviated, and their power subject to no finite restraint. To prove this, it will be only necessary to remark, that the force of any machine acting upon this principle can be increased *ad infinitum*, either by extending the proportion between the diameter of the injector and the cylinder A, or by applying greater power to the lever H.

"Fig 5. represents the section of an engine, by which very wonderful effects may be produced instantaneously by means of compressed air. AA is a cylinder, with the piston B fitting air-tight, in the same manner as described in fig. 4. C is a globular vessel made of copper, iron, or other strong materials, capable of resisting immense force, similar to those of air guns. D is a strong tube of small bore, in which is the stop-cock E. One of the ends of this tube communicates with the cylinder under the piston B, and the other with the globe C. Now, suppose the cylinder A to be the same diameter as that in fig. 4. and the tube D equal to one quarter of an inch diameter, which is the same as the injector fig. 4.: then, suppose that air is injected into the globe C (by the common method), till it presses against the cock E with a force equal to 20 cwt. which can easily be done; the consequence will be, that when the cock E is opened, the piston B will be moved in the cylinder AA with a power or force equal to 2304 tons; and it is obvious, as in the case fig. 4. that any other unlimited degree of force may be acquired by machines or engines thus constructed.

"Fig. 6. is a section, merely to shew how the power and motion of one machine may, by means of fluids, be transferred or communicated to another, let their distance and local situation be what they may. A and B are two small cylinders, smooth and cylindrical; in the inside of each of which is a piston, made water and air tight, as in figs 4. and 5. CC is a tube conveyed under ground, or otherwise, from the bottom of one cylinder to the other, to form a communication between them, notwithstanding their distance be ever so great; this tube being filled with water or other fluid, until it touch the bottom of each piston; then, by depressing the piston A, the piston B will be raised. The same effect will be produced *vice versa*: thus bells may be rung, wheels turned, or other machinery put invisibly in motion, by a power being applied to either.

"Fig. 7. is a section, shewing another instance of communicating the action and force of one machine to another; and how water may be raised out of wells of any depth, and at any distance from the place where the operating power is applied. A is a cylinder of any required dimensions, in which is the working piston B, as in the foregoing examples: into the bottom of this cylinder is inserted the tube C, which may be of less bore than the cylinder A. This tube is continued, in any required direction, down to the pump cylinder D, supposed to be fixed in the deep well EE, and forms a junction therewith above the piston F; which piston has a rod G, working through the stuffing-box, as is usual in a common pump. To this rod G is connected, over a pulley or otherwise, a weight H, sufficient to overbalance the weight of the water in the tube C, and to raise the piston F when the piston B is lifted: thus, suppose the piston B is drawn up by its rod, there will be a vacuum made in the pump cylinder D, below the piston F; this vacuum will be filled with water through the suction pipe, by the pressure of the atmosphere, as in all pumps fixed in air. The return of the piston B, by being pressed downwards in the cylinder A, will make a stroke of the piston in the pump cylinder D, which may be repeated in the usual way by the motion of the piston B, and the action of the water in the tube C. The rod G of the piston F, and the weight H, are not necessary in wells of a depth where the atmosphere will overbalance the water in the suction of the pump cylinder D, and that in the tube C. The small tube and cock in the cistern I, are for the purpose of charging the tube C."

That these contrivances are ingenious, and may occasionally prove useful, we are not inclined to controvert; but we must confess, that the advantages of them appear

appear not to us so great as to their author. Why they do not, we need not explain to any man who, with a sufficient degree of mechanical and mathematical knowledge, has perused this article with attention. *Mr John Luccock*, however, of Marley, near Leeds, thinks so very differently from us on this subject, that, on Mr Bramah's principle, he proposes to apply water or other dense fluids, so as to make them supply the place of steam in what is commonly called the *steam engine*. He calls his engine the *paradoxical machine*; and he got a patent for it on the 28th of February 1799, though it differs in nothing from Mr Bramah's machine, represented by fig. 4. except that the tube C in the paradoxical machine is supplied with water, not by means of a forcing pump, but from a cistern elevated to such a height as, that the water descending through the tube may produce its effect merely by its weight. Whether this variation, for it is no improvement, of Mr Bramah's machine intitled its author to a patent, it is not our business to inquire.

Macpherson.

MACPHERSON (James, Esq;), was born in the parish of Kingusie, and county of Inverness, in the year 1738. His father was a farmer of no great affluence; and young Macpherson received the earlier part of his education in one of the parish schools in the district called Badenoch. By an anonymous writer in the Edinburgh Magazine, he is said to have been educated in the grammar school of Inverness; and he may, for ought that we know to the contrary, have spent a year in that seminary; but we rather think that he went directly from a country school to the university of Aberdeen. At this our readers need not be surprised; for at the period to which we refer, some of the parochial schoolmasters in Scotland, and more especially in the Highlands, were men eminent for taste and classical literature.

It was in the end of October or the 1st of November 1752, that James Macpherson entered the King's College; where he displayed more genius than learning, entertaining the society of which he was a member, and even diverting the younger part of it from their studies, by his humorous and doggerel rhimes. About two years after his admission into the university, the King's College added two months to the length of its annual *session* or *term*; which induced Macpherson, with many other young men, to remove to the Marischal College, where the session continued short; and it is this circumstance which leads us to suppose that his father was not opulent.

Soon after he left college, and perhaps before he left it, he was schoolmaster of Ruthven, or Riven, of Badenoch; and we believe he afterwards delighted as little as his great antagonist Johnson in the recollection of that period when he was compelled, by the narrowness of his fortune, to teach boys in an obscure school. It was during this period, we think in 1758, that he published *The Highlander*, an heroic poem in six cantos, 12mo. Of this work, as we have never seen it, we can say nothing. By the anonymous writer already quoted, it is mentioned as a "tissue of fustian and absurdity;" whilst others, and they too men of learning and character, have assured us, that it indicated considerable genius in so young an author.

Soon after this publication, Mr Macpherson quitted his school, and was received by Mr Graham of Balgowan into his family as tutor to his sons; an employment of which he was not fond, and to which he was not long condemned. In the year 1760 he surprised the world by the publication of *Fragments of Ancient Poetry, collected in the Highlands of Scotland, and Translated from the Gaelic or Erse Language*, 8vo. These fragments, which were declared to be genuine remains of ancient Scottish poetry, at their first appearance delighted every reader; and some very good judges, and amongst the rest Mr Gray, were extremely warm in their praises. Macpherson had intended to bury them in a Scotch magazine, but was prevented from so injudicious a step by the advice of a friend. He published them therefore in a pamphlet by themselves, and thus laid the foundation of his future fortune.

Macpherson.

As other specimens were said to be recoverable, a subscription was set on foot by the Faculty of Advocates at Edinburgh, to enable our author to quit the family of Balgowan, perambulate the Highlands, and secure, if he could, the precious treasure. He engaged in the undertaking, and was successful; for all who possessed any of the long famed works, vied with each other in giving or sending them to a man who had shewn himself so capable of doing them justice.

With his collection of poems, and fragments of poems, he went to London; and tagging them together in the form which he thought best, he published, in 1762, *Fingal, an Ancient Epic Poem, in six books*, together with several other poems, composed by Ossian the son of Fingal, translated from the Gaelic language. 4to. The subject of this epic poem is an invasion of Ireland by Swaran king of Lochlin. Cuchullin, general of the Irish tribes during the minority of Cormac king of Ireland, upon intelligence of the invasion, assembled his forces near Tura, a castle on the coast of Ulster. The poem opens with the landing of Swaran; councils are held, battles fought, and Cuchullin is at last totally defeated. In the mean time, Fingal, king of the Highlands of Scotland, whose aid had been solicited before the enemy landed, arrived, and expelled them from the country. This war, which continued but six days and as many nights, is, including the episodes, the story of the Poem. The scene, the heath of Lena, near a mountain called Cromleach in Ulster. This poem also was received with equal applause as the preceding Fragments.

The next year he produced *Temora*, an ancient epic poem, in eight books; together with several other poems composed by Ossian son of Fingal, 4to, which, though well received, found the public somewhat less disposed to bestow the same measure of applause. Tho' these poems had been examined by Dr Blair and others, and their authenticity asserted, there were not wanting some of equal reputation for critical abilities, who either doubted or declared their disbelief of the genuineness of them.

Macpherson.

them. Into this question it would be superfluous to enter here particularly, as we have said enough on it elsewhere. See Ossian, *Encycl.*

That any man should suppose Macpherson, after his translation of Homer, the *author* of the poems which he ascribes to Ossian, appears to us very extraordinary; and it is little less extraordinary, that any one should, for a moment, believe in the existence of *manuscripts* of these poems of *very high* antiquity. Part of them he undoubtedly received in manuscript from Macdonald of Clanronald; but we can affirm, on the best authority, that the said manuscript was written at different times by the Macvuirichs, hereditary bards to that family. He may likewise have received short manuscripts elsewhere; but every Highland gentleman of learning and of candour (and none else have a right to decide on this question), declares, that by much the greater part of the poems had been preserved in fragments and popular songs from a very remote age by oral tradition. To these fragments Macpherson and his associates (A) gave form; and it was by uniting together fragments of different ages, that he inadvertently furnished Gibbon and others with the opportunity of objecting, that the poems are sometimes inconsistent with the truth of history. This, however, is no solid objection to their authenticity; for every West Highlander fifty years of age remembers to have heard, in his youth, great part of those poems repeated by old men; and is confident that, many centuries ago, the names of *Fion Mackuil* (Fingal), and of Ossian's other heroes and heroines, were as familiar to a Highland ear, as the names of Agamemnon, Hector, Helen, &c. were to a Grecian ear at the time when the poems of Homer were reduced into their present form. For the substance of the poems, this is such evidence as none will reject who does not prefer his own cobweb theories to the united testimony of a whole people.

With respect to authenticity, the poems of Ossian have indeed been compared with the poems of Rowley; but the comparison is absurd. The poems of the Celtic bard were not found in an old chest, and presented to a people who had never before heard either of them or of their author; they were the popular songs and traditions of ages collected together, and reduced into form, with additions occasionally made by the translator. It is ridiculous to ask how these songs and stories could be so long preserved among a rude and illiterate people; for it is only among such a people, whose objects of pursuit are too few to occupy all their attention, that the exploits of their ancestors can be handed down by tradition; and the most serious objection which we have ever met with to the translator's account of the origin of the poems, arises from his having pretended that he received the greater part of them in old manuscripts.

After the publication of Ossian's poems, by which we have reason to believe that he gained twelve hundred pounds, Mr Macpherson was called to an employment which withdrew him, for some time, both from the muses and from his country. Captain Johnstone was appointed governor of Pensacola, and Mr Macpherson accompanied him as his secretary, being at the same time made surveyor general of the Floridas. If our memory does not deceive us, some difference arose between the principal and his dependant, and they parted before their return to England. Having contributed his aid to the settlement of the civil government of that colony, he visited several of the West India islands, and some of the provinces of North America, and returned to England in the year 1766, where he retained for life his salary as surveyor, which we believe was L. 200 a year.

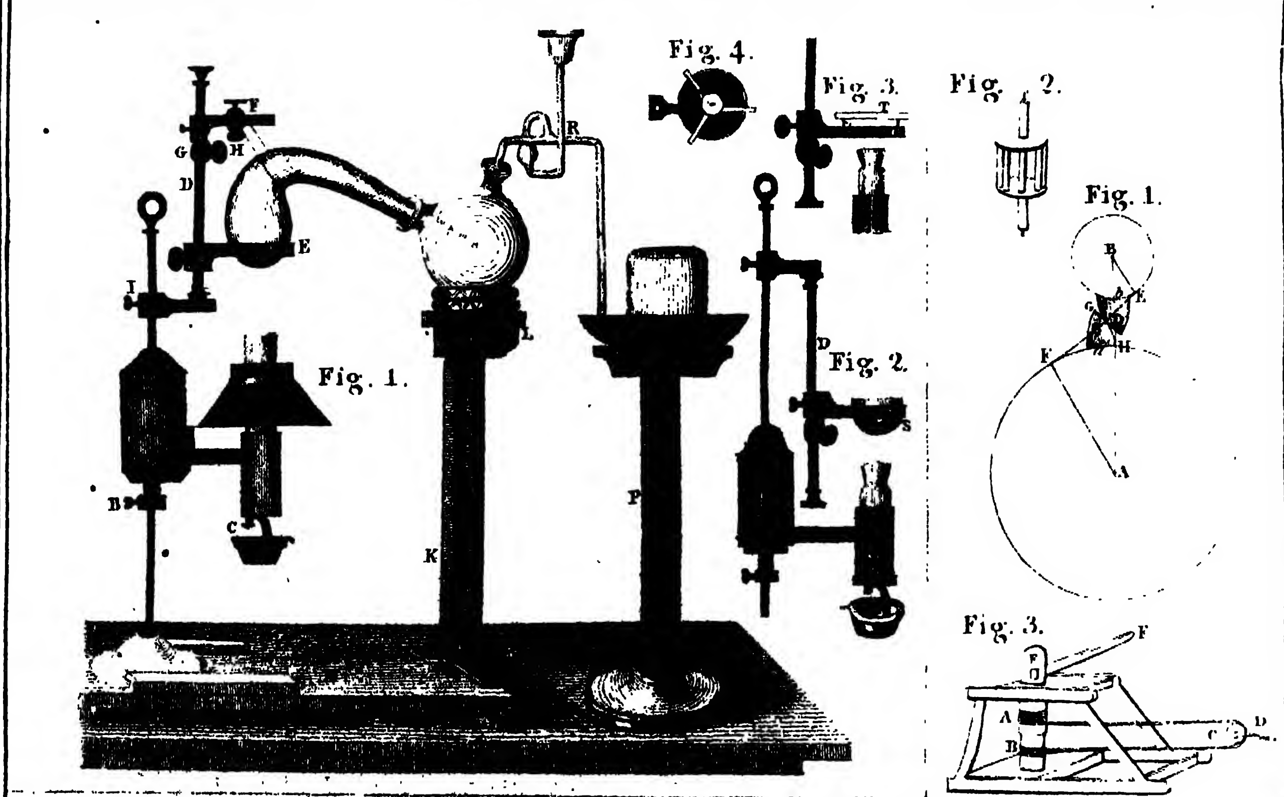
He soon returned to his studies, and in 1771 produced *An Introduction to the History of Great Britain and Ireland*, 4to; a work which he says, "without any of the ordinary incitements to literary labour, he was induced to proceed in by the sole motive of private amusement." The subject of this performance, it might reasonably be supposed, would not excite any violent controversial acrimony; yet neither it nor its author could escape from several most gross and bitter invectives, for some of which he perhaps gave too great occasion.

His next performance produced him neither reputation nor profit. In 1773 he published, *The Iliad of Homer*, translated in two volumes 4to; a work fraught with vanity and self-consequence, and which met with the most mortifying reception from the public. It was condemned by the critics, ridiculed by the wits, and neglected by the world. Some of his friends, and particularly Sir John Elliott, endeavoured to rescue it from contempt, and force it into notice. Their success was not equal to their efforts.

About this time seems to be the period of Mr Macpherson's literary mortifications. In 1773 Dr Johnson and Mr Boswell made their tour to the Hebrides, and in the course of it, the former took some pains to examine into the proofs of the authenticity of Ossian. The result of his inquiries he gave to the public in 1775, in his narrative of the tour; and his opinion was unfavourable. "I believe they (*i. e.* the poems, says he), never existed in any other form than that which we have seen. The editor or author never could shew the original; nor can it be shewn by any other. To revenge reasonable incredulity by refusing evidence, is a degree of insolence with which the world is not yet acquainted; and stubborn audacity is the last refuge of guilt. It would be easy to shew it if he had it. But whence could it be had? It is too long to be remembered, and the language had formerly nothing written. He has doubtless inserted names that circulate in popular stories, and may have translated some wandering ballads, if any can be found; and the names and some of the images being recollected, make an inaccurate auditor imagine that he has formerly heard the whole."

Again, he says, "I have yet supposed no imposture but in the publisher; yet I am far from certainty, that some translations have not been lately made, that may

(A) We have been assured that he had associates: and that for the description of Cuchullin's chariot in particular he was indebted to Mr Macpherson of *Stramasbi*. a man of native genius, and though not possessed of very extensive erudition, well acquainted with Gaelic poetry.



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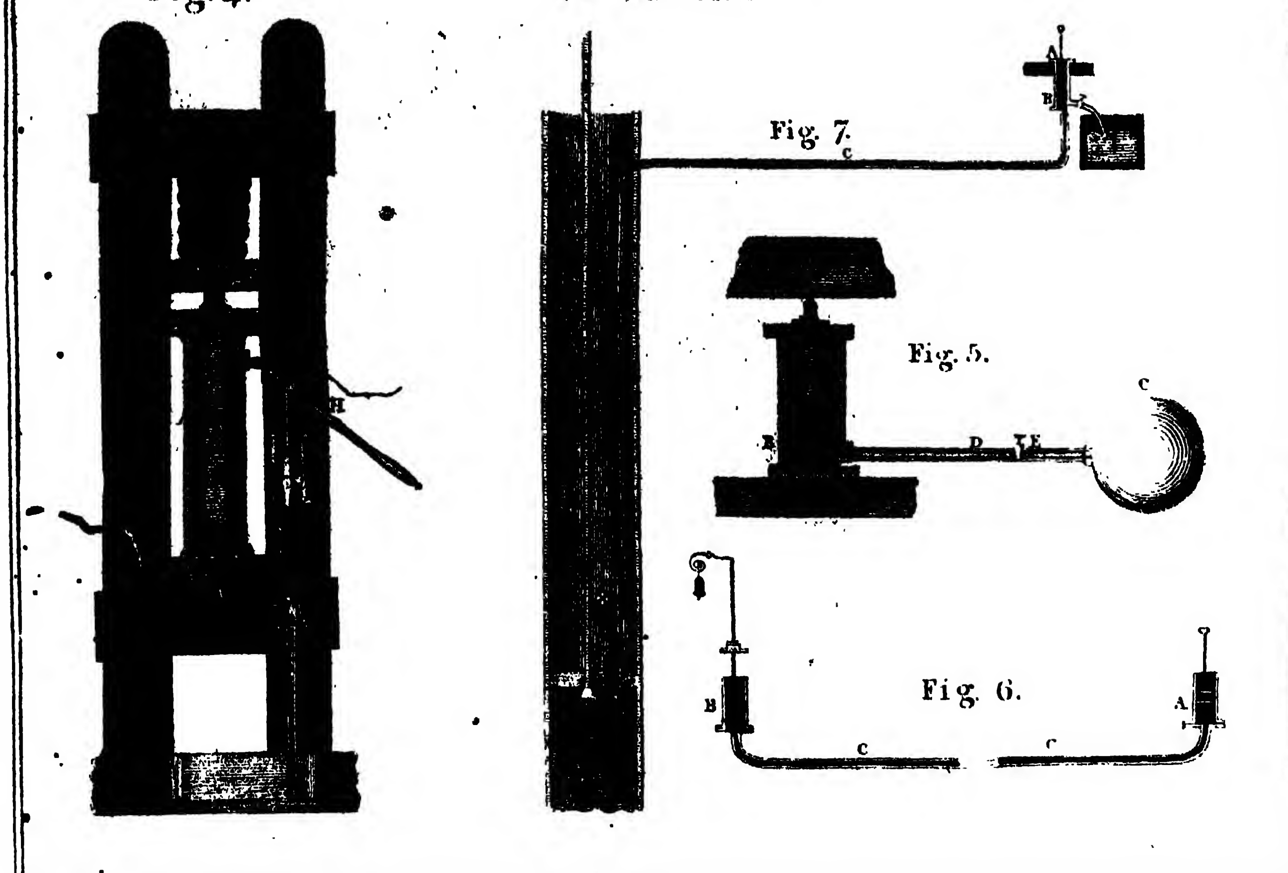

may now be obtruded as parts of the original work.

"Credulity on the one part is a strong temptation to deceit on the other, especially to deceit of which no personal injury is the consequence, and which flatters the author with his own ingenuity. The Scots have something to plead for their easy reception of an improbable fiction: they are seduced by their fondness for their supposed ancestors. Neither ought the English to be much influenced by Scotch authority; for of the past and present state of the whole Erse nation, the Lowlanders are at least as ignorant as ourselves. To be ignorant is painful; but it is dangerous to quiet our uneasiness by the delusive opiate of hasty persuasion."

These reasonings, if reasonings they can be called, might have been easily answered, had not Macpherson pretended to the possession of at least one manuscript which certainly never existed. He did not, however, attempt to answer them; but adopted a mode of proceeding which tended only to convince the world that Johnson's opinion had some foundation, and that the editor of Ossian had more imagination than sound judgement. Prompted by his evil genius, he sent a menacing letter to his illustrious antagonist, which produced the following brief but spirited reply:

"Mr James Macpherson, No date.

"I received your foolish and impudent letter. Any violence that shall be offered to me, I will do my best to repel; and what I cannot do for myself, the law shall do for me; for I will not be hindered from exposing what I think a cheat, by the menaces of a ruffian. What! Would you have me retract? I thought your work an imposition: I think so still; and, for my opinion, I have given reasons, which I dare you to refute. Your abilities, since your *Homer*, are not so formidable; and what I hear of your morality, inclines me to believe rather what you shall prove than what you shall say."

Whether this letter shewed to Macpherson the imprudence of his conduct, or that he had been made sensible of his folly by the interposition of friends, we know not; but certain it is, we hear no more afterwards of this ridiculous affair, except that our author is supposed to have assisted Mr Macnicol in an answer to Dr Johnson's Tour, printed in 1779. This supposition we are inclined to consider as well founded, because we have been told by a gentleman of veracity, that Mr Macnicol affirms, that the scurrility of his book, which constitutes a great part of it, was inserted, unknown to him, after the manuscript was sent for publication to London.

In 1775 Mr Macpherson published *The History of Great Britain from the Restoration to the Accession of the House of Hanover*, in two volumes 4to; a work in our opinion of great merit, though by one party it has been industriously, and, we are sorry to add, too successfully, decried. As an historian, our author could not indeed boast the attic elegance of a Robertson, the splendour of a Gibbon, or the philosophical profundity of a Hume; but his *style*, though it has sometimes been the avowed, was not the real cause of the coldness with which his history was received. The writer of this sketch once saw a gentleman of rank, and of the Whig interest, turn over one of Macpherson's volumes, and heard him say, upon shutting the book, "I cannot bear that work." He was asked if he thought the narrative false? and he replied, "No! It is too true; but I cannot bear it, because it gives me a bad opinion of those great men to whom I have been accustomed to look back with reverence as to the saviours of my country."

That it has been abhorred by others on the same account, we have not a doubt; and yet language has no name too contemptuous for those who will not follow truth whithersoever she may lead them; or who, on the absurd pretence of having already made up their minds, will not study the evidence on both sides of a disputed question in our national history. A man needs not surely disapprove of the Revolution, or of the subsequent settlements, though he should find complete proofs that Danby and Sunderland were crooked politicians, that Marlborough was ungrateful, or even that King William himself was not that upright and disinterested character which from their infancy they have been taught to believe. It is no uncommon thing for Divine Providence to accomplish good ends by wicked instruments. Every Protestant surely considers the Reformation as one of the most blessed events that have taken place in the world since the first preaching of the gospel of Christ; yet he would be a hardy champion who should undertake to vindicate the motives which influenced the conduct of the first reformers—of Henry VIII. for instance, or even of Luther himself. And why may not the Revolution be considered as in the highest degree beneficial to the country, though the conduct of some of those who brought it about should be found to be such as Macpherson represents it?

That author certainly acted with great fairness; as together with the history he published the proofs upon which his facts were founded, in two quarto volumes, intitled, *Original Papers, containing the secret History of Great Britain, from the Restoration to the Accession of the House of Hanover; to which are prefixed, Extracts from the Life of James II. as written by himself.* These papers were chiefly collected by Mr Carte, but are not all of equal authority. They, however, clear up many obscurities, and set the characters of many persons in past times in a different light from that in which they have been usually viewed. On this account we have no hesitation to say, that he who is capable of sacrificing prejudice to truth, and wishes to understand the politics of the reigns of James, and William, and Anne, should study with care the volumes of Macpherson.

Soon after this period, the tide of fortune flowed very rapidly in Mr Macpherson's favour, and his talents and industry were amply sufficient to avail himself of every favourable circumstance which arose. The resistance of the Colonies called for the aid of a ready writer to combat the arguments of the Americans, and to give force to the reasons which influenced the conduct of government, and he was selected for the purpose. Among other things (of which we should be glad to receive a more particular account), he wrote a pamphlet, which was circulated with much industry, intitled, *The Rights of Great Britain asserted against the Claims of the Colonies; being an Answer to the Declaration of the General Congress*, 8vo, 1776, and of which many editions were published. He also was the author of *A Short History of Opposition during the last Session of Parliament*,

Macpherson. *Parliament*, 8vo, 1779; a pamphlet which, on account of its merit, was by many ascribed to Mr Gibbon.

But a more lucrative employment was conferred on him about this time. He was appointed agent to the nabob of Arcot, and in that capacity exerted his talents in several appeals to the public in behalf of his client. Among others, he published, *Letters from Mahommed Ali Chan, Nabob of Arcot, to the Court of Directors; to which is annexed, a State of Facts relative to Tanjore, with an Appendix of Original Papers*, 4to, 1777; and he was supposed to be the author of *The History and Management of the East India Company from its Origin in* 1600 *to the present Times*, vol. i. containing the affairs of the Carnatic, in which the rights of the nabob are explained, and the injustice of the Company proved, 4to, 1779.

In his capacity of agent to the nabob, it was probably thought requisite that he should have a seat in the British Parliament. He was accordingly in 1780 chosen member for Camelford; but we do not recollect that he ever attempted to speak in the House. He was also rechosen in 1784 and 1790.

He had purchased, we think before the year 1790, an estate in the parish in which he was born; and changing its name from *Retz* to *Belville*, built on it a large and elegant mansion, commanding a very romantic and picturesque view; and thither he retired, when his health began to fail, in expectation of receiving benefit from the change of air. He continued, however, to decline; and after lingering some time, died at his seat at Belville, in Inverness, on the 17th of February 1796.

He appears to have died in very opulent circumstances; and by his will, dated June 1793, gave various annuities and legacies to several persons to a great amount. He also bequeathed L. 1000 to John Mackenzie of Figtree Court, in the Temple, London, to defray the expence of printing and publishing Ossian in the original. He directed L. 300 to be laid out in erecting a monument to his memory in some conspicuous situation at Belville, and ordered that his body should be carried from Scotland, and interred in the Abbey Church of Westminster, the city in which he had passed the best part of his life. His remains were accordingly taken from the place where he died, and buried in the Poets Corner of Westminster church.

Macpherson, Magma.

MAGMA is properly the *refuse* of any substance which has been subjected to pressure; but, in chemistry, the term is sometimes used to denote a mixture of two or more bodies, reduced to the consistence of dough or paste.

MAGNETISM.

IN natural philosophy.—Our intention in the present article was principally to give a more distinct account of the theory of Mr Æpinus than is contained in the article MAGNETISM of the *Encyclopedia Britannica*, referring for proof and illustration to the many facts contained in that article: but, on more mature consideration, we concluded, that this method would fret and confuse the reader by continual references, and leave but a feeble impression at last. We have therefore preferred the putting the whole into the form of a short treatise on magnetism, similar to our supplementary article of ELECTRICITY. This, we hope, will be more perspicuous and satisfactory; still leaving to the reader the full use of all the information contained in the article MAGNETISM of the Dictionary.

1 Reasons why the ancients knew so little of natural philosophy.

The knowledge which the antient naturalists possessed of this subject was extremely imperfect, and affords, we think, the strongest proof of their ignorance of the true method of philosophising; for there can hardly be named any object of physical research that is more curious in itself, or more likely to engage attention, than the apparent life and activity of a piece of rude unorganised matter. This had attracted notice in very early times; for Thales attributed the characteristic phenomenon, the attraction of a piece of iron, to the agency of a mind or soul residing in the magnet. Philosophers, as they were called, seem to have been contented with this lazy notice of a slight suggestion, unbecoming an inquirer, and rather such as might be expected from the most incurious peasant. Even Aristotle, the most zealous and the most systematic student of Nature of whose labours we have any account, has collected no information that is of any importance. We know that the general imperfection of ancient physics has been ascribed to the little importance that was attached to the knowledge of the material world by the philosophers of Greece and Rome, who thought human nature, the active pursuits of men, and the science of public affairs, the only objects deserving their attention. Most of the great philosophers of antiquity were also great actors on the stage of human life, and despised acquisitions which did not tend to accomplish them for this dignified employment: but they have not given this reason themselves, though none was more likely to be uppermost in their mind. Socrates dissuades from the study of material nature, not because it was unworthy of the attention of his pupils, but because it was too difficult, and that certainty was not attainable in it. Nothing can more distinctly prove their ignorance of what is really attainable in science, namely, the knowledge of the *laws of nature*, and their ignorance of the only method of acquiring this knowledge, viz. observation and experiment. They had entertained the hopes of discovering the *causes* of things, and had formed their philosophical language, and their mode of research, in conformity with this hopeless project. Making little advances in the discovery of the causes of the phenomena of material nature, they deserted this study for the study of the conduct of man; not because the discovery of causes was more easy and frequent here, but because the study itself was more immediately interesting, and because any thing like superior knowledge in it puts the possessor in the desirable situation of an adviser, a man of superior wisdom; and as this study was closely connected with morals, because the fear of God is truly the beginning of wisdom, the character of the philosopher acquired an eminence and dignity which was highly flattering to human vanity. Their procedure in the moral and intellectual sciences is strongly marked with the same ignorance of the true method of philo-

philosophising; for we rarely find them forming general propositions on copious inductions of facts in the conduct of men. They always proceed in the synthetic method, as if they were fully conversant in the first principles of human nature, and had nothing to do but to make the application, according to the established forms of logic. While we admire, therefore, the sagacity, the penetration, the candid observation, and the happy illustration, to be found in the works of the ancient moralists and writers on jurisprudence and politics, we cannot but lament that such great men, frequently engaged in public affairs, and therefore having the finest opportunities for deducing general laws, have done so little in this way; and that their writings, however engaging and precious, cannot be considered as any thing more refined than the observations of judicious and worthy men, with all the diffuseness and repetition of ordinary conversation. All this has arisen from the want of a just notion of what is attainable in this department of science, namely, the laws of intellectual and moral nature; and of the only possible method of attaining this knowledge, viz. observation and experiment, and the formation of general laws by the induction of particular facts.

2 Dr Gilbert was the first experimental enquirer about magnetism.

We have been led into these reflections by the inattention of the ancients to the curious phenomena of magnetism; which must have occurred in considerable and entertaining variety to any person who had taken to the experimental method. And we have hazarded these free remarks, expecting the acquiescence of our readers, because the superior knowledge which we, in these later days, have acquired of the magnetical phenomena, were the first fruits of the true method of philosophising. This was pointed out to the learned world in 1590 by our celebrated countryman Chancellor Bacon, in his two great works, the *Novum Organum Scientiarum*, and *De Argumentis Scientiarum*. Dr Gilbert of Colchester, a philosopher of eminence in many respects, but chiefly because he had the same just views of philosophy with his noble countryman, published about the same time his *Physiologia Nova, seu Tractatus de Magnete et Corporibus magneticis*. In the introduction, he recounts all the knowledge of the antients on the subject, and their supine inattention to what was so entirely in their hands; and the impossibility of ever adding to the stock of useful knowledge, so long as men imagined themselves to be philosophising while they were only repeating a few cant words, and the unmeaning phrases of the Aristotelian school. It is curious to remark the almost perfect sameness of Dr Gilbert's sentiments and language with those of Lord Bacon. They both charge, in a peremptory manner, all those who pretend to inform others, to give over their dialectic labours, which are nothing but ringing changes on a few trite truths, and many unfounded conjectures, and immediately to betake themselves to experiment. He has pursued this method on the subject of magnetism with wonderful ardour, and with equal genius and success; for Dr Gilbert was possessed both of great ingenuity, and a mind fitted for general views of things. The work contains a prodigious number and variety of observations and experiments, collected with sagacity from the writings of others, and instituted by himself with considerable expence and labour. It would indeed be a miracle, if all Dr Gilbert's general inferences were just, or all his experiments accurate. It was untrodden ground. But, on the whole, this performance contains more real information than any writing of the age in which he lived, and is scarcely exceeded by any that has appeared since. We may hold it with justice as the first fruits of the Baconian or experimental philosophy.

This work of Dr Gilbert's relates chiefly to the loadstone, and what we call magnets, that is, pieces of steel which have acquired properties similar to those of the loadstone. But he extends the term *magnetism*, and the epithet *magnetic*, to all bodies which are affected by loadstones and magnets in a manner similar to that in which they affect each other. In the course of his investigation, indeed, he finds that these bodies are only such as contain iron in some state or other: and in proving this limitation he mentions a great variety of phenomena which have a considerable resemblance to those which he allows to be magnetical, namely, those which he called *electrical*, because they were produced in the same way that amber is made to attract and repel light bodies. He marks with care the distinctions between these and the characteristic phenomena of magnets. He seems to have known, that all bodies may be rendered electrical, while ferrugineous substances alone can be made magnetical.

It is not saying too much of this work of Dr Gilbert's to affirm, that it contains almost every thing that we know about magnetism. His unwearied diligence in searching every writing on the subject, and in getting information from navigators, and his incessant occupation in experiments, have left very few facts unknown to him. We meet with many things in the writings of posterior inquirers, some of them of high reputation, and of the present day, which are published and received as notable discoveries, but are contained in the rich collection of Dr Gilbert. We by no means ascribe all this to mean plagiarism, although we know traders in experimental knowledge who are not free from this charge. We ascribe it to the general indolence of mankind, who do not like the trouble of consulting originals, where things are mixed with others which they do not want, or treated in a way, and with a painful minuteness, which are no longer in fashion. Dr Gilbert's book, although one of those which does the highest honour to our country, is less known in Britain than on the continent. Indeed we know but of two British editions of it, which are both in Latin; and we have seen five editions published in Germany and Holland before 1628. We earnestly recommend it to the perusal of the curious reader. He will (besides the sound philosophy) find more facts in it than in the two large folios of Scarella.

After this most deserved eulogy on the parent of magnetical philosophy, it is time to enter on the subject.

4 [illegible] the

In mechanical philosophy, a phenomenon is not to be considered as explained, unless we can shew that it is the certain result of the laws of motion applied to matter. It is in this way that the general propositions in physical astronomy, in the theory of machines, in hydraulics, &c. are demonstrated. But the phenomena called *magnetical* have not as yet obtained such an explanation. We do not see their immediate cause, nor can we say with confidence that they are the effects of any

ary particular kind of matter, acting on the bodies either by impulsion or pressure.

All that can be done here is to class the phenomena in the most distinct manner, according to their generality. In this we obtain a two-fold advantage. We may take it for granted that the most general phenomenon is the nearest allied to the general cause. But, farther, we obtain by this method a true theory of all the subordinate phenomena. For a just theory is only the pointing out the general fact of which the phenomenon under consideration is a particular instance. Beginning therefore with the phenomenon which comprehends all the particular cases, we explain those cases in shewing *in what manner* they are included in the general phenomenon, and thus we shall be able to predict what will be the result of putting the body under consideration into any particular situation. And perhaps we may find, in them all, coincidences which will enable us to shew that they are all modifications of a fact still more general. If we gain this point, we shall have established a complete theory of them, having discovered the general fact in which they are all comprehended. Should we for ever remain ignorant of the cause of this general fact, we have nevertheless rendered this a complete branch of mechanical theory. Nay, we may perhaps discover such circumstances of resemblance between this general fact and others, with which we are better acquainted, that we shall, with great probability at least, be able to assign the cause of the general fact itself, by shewing the law of which it is a particular instance.

We shall attempt this method on the present occasion.

5
Leading facts.

The leading facts in magnetism are the two following:

[illegible]

1. If any oblong piece of iron, such as a bar, rod, or wire, be so fitted, that it can assume any direction, it will arrange itself in a certain determinate direction with respect to the axis of the earth. Thus, if, in any part of Britain, an iron or steel wire be thrust through a piece of cork, as represented in fig. 1. so as that the whole may swim level in water, and if it be laid in the water nearly north-west and south-east, it will slowly change its position, and finally settle in a direction, making an angle of about 25 degrees with the meridian.

Plate [illegible]XIV.

This experiment, which we owe to Dr Gilbert (see B. I. ch. 11.), is delicate, and requires attention to many circumstances. The force with which the iron tends toward this final position is extremely weak, and will be balanced by very minute and otherwise insensible resistances; but we have never found it fail when executed as here directed. An iron wire of the size of an ordinary quill, and about eight or ten inches long, is very fit for the purpose. It should be thrust through the cork at right angles to its axis; and so adjusted, by repeated trials, as to swim level or parallel to the horizon. The experiment must also be made at a great distance from all iron; therefore in a bason of some other metal or earthen ware. It may sometimes require a very long while before the motion begin; and if the wire has been placed at right angles to the direction which we have mentioned as final, it will never change its position: therefore we have directed it to be laid in a direction not too remote, yet very sensibly different from the final direction.

But this is not the true position [illegible] iron rod. If it be thrust through a pi[illegible] of wood or cork perfectly spherical, in such a manner that it passes thro' its centre, and if the centre of gravity coincide with this centre, and the whole be of such weight as to remain in any part of the water, without either ascending or descending, then it will finally settle in a plane inclined to the meridian about 25°, and the north end will be depressed about 73 below the horizon.

All this is equivalent with saying, that if any oblong piece of iron or steel be very nicely poised on its centre of gravity, and at perfect liberty to turn round that centre in every direction, it will finally take the position now mentioned.

We have farther to observe with regard to this experiment, that it is indifferent which end of the rod be placed toward the north in the beginning of the experiment. That end will finally settle toward the north; and if the experiment be repeated with the same rod, but with the other end north, it will finally settle in this new attitude. It is, however, not always that we find pieces of iron thus perfectly indifferent. Very frequently one end affects the northerly position, and we cannot make the other end assume its place: the causes of this difference will be clearly seen by and bye.

6
Magnetical position.

The position thus affected by a rod of iron is called by Dr Gilbert the MAGNETICAL POSITION OR DIRECTION. It is not the same, nor parallel, in all parts of the earth, as will be more particularly noticed afterwards.

7
Second fact.
Iron attracts and repels iron.

[illegible] a piece of iron, [illegible] or nearly so, and at [illegible] every direction, is ap-pr[illegible]iece of iron, held nearly in [illegible]y it; that is, the moveable [illegible] to the one that [illegible] at last come into contact with it, and may [illegible] be slowly drawn along by it.

This phenomenon, although not so delicate as the former, is still very nice, because the attraction is so weak that it is balanced by almost insensible obstructions. But the experiment will scarcely fail if conducted as follows: Let a strong iron wire be made to float on water by means of a piece of cork, in the manner already described, having one end under water. See fig. 1. B.

When it is nearly in the magnetical position, bring the end of a pretty big iron rod, such as the point of a new poker, within a quarter of an inch of its southern end (holding the poker in a position not very different from the magnetical position), and hold it there for some time, not exactly southward from it, but a little to one side. The floating iron will be observed to turn towards it with an accelerated motion; will touch it, and may then be drawn by it through the water in any direction. We shall have the same result by approaching the northern extremity of the floating iron with the upper end of the poker.

The same phenomenon may be observed by suspending the first piece of iron by its middle by a long and slender hair or thread. The suspension must be long, otherwise the stiffness of the hair or thread may be sufficient for balancing the very small force with which the pieces of iron tend toward each other. The phenomenon

non may also be observed in a piece of iron which turns freely on a fine point, like the needle of the mariner's compass.

In this, as in the former experiment, the ends of the pieces of iron are observed, in general, to be indifferent; that is, either end of the one will attract either end of the other. It often happens, however, that the ends are not thus indifferent, and that the end of the moveable piece of iron, instead of approaching the other, will be observed to recede from it, and appear to avoid it. We shall soon learn the cause of this difference in the states of iron.

This action mutual. It is scarcely necessary to remark, that we must infer from these experiments, that the action is mutual between the two pieces of iron. Either of them may be the moveable piece which approaches the other, manifesting the attraction of that other. This reciprocity of action will be abundantly verified and explained in its proper place.

9 Not peculiar to magnets or loadstone; These two facts were long thought to be peculiar to loadstones and artificial magnets, that is, pieces of iron which have acquired this property by certain treatment with loadstones; but they were discovered by Dr Gilbert to be inherent in all iron in its metallic state; and were thought by him to be necessary consequences of a general principle in the constitution of this globe. These phenomena are indeed much more conspicuous in loadstones and magnets; and it is therefore with such that experiments are best made for learning their various modifications.

10 ...at, in iron, indifferent, and ...omentary, and in loadstones, is fixed and determinate. But there is another circumstance, besides the degree of vivacity, in which the magnetism of common iron and steel remarkably differs from that of a loadstone or magnet. When a loadstone or magnet is so supported as to be at liberty to take any position, it arranges itself in the magnetical direction, and *one determined end* of it settles in the northern quarter; and if it be placed so that the other end is in that situation, it does not remain there, but gradually turns round, and, after a few oscillations, the *same end* ultimately settles in the north. This is distinctly seen in the needle of the mariner's compass, which is just a small magnet, prepared in the same way with all other magnets. The several ends of loadstones or magnets are thus permanently the north or the south ends; whereas we said that either end of a piece of common iron being turned to the northern quarter, it finally settles there.

It is this circumstance which has rendered magnetism so precious a discovery to mankind, by furnishing us with the compass, an instrument by which we learn the different quarters of the horizon, and which thus tells the direction of a ship's course through the pathless ocean (see COMPASS and VARIATION, *Encycl.*); and also shews us the directions of the veins and workings in the deepest mines. It was natural therefore to call those the north and south ends of the mariner's needle, or of a loadstone or magnet. Dr Gilbert called them the POLES of the loadstone or magnet. He had found it convenient for the proposed train of his experiments to form his loadstones into spheres, which he called TERRELLÆ, from their resemblance to this globe; in which case the north and south ends of his loadstones were the poles of the terrellæ. He therefore gave the name *pole* to that part of any loadstone or magnet which thus turned to the north or south. The denomination was adopted by all subsequent writers, and now makes a term in the language of magnetism.

Also, when we approach either end of a piece of iron A to either end of another B, these ends mutually attract; or if either end of a magnet A be brought near either end of a piece of common iron, they mutually attract each other. But if we bring that end of a magnet A which turns to the north near to the *similar* end of another magnet B, these ends will not attract each other, but, on the contrary, will repel. If the two magnets are made to float on pieces of wood, and have their north poles fronting each other, the magnets will retire from each other; and in doing so, they generally turn round their axes, till the north pole of one front the south pole of the other, and then they run together. This is a very notable distinction between the magnetism of magnets and that of common iron; and whenever we see a piece of iron shew this permanent distinction of its ends, we must consider it as a magnet, and conclude that it has met with some peculiar treatment.

It is not, however, strictly true, that the poles of loadstones or magnets are so fixed in particular parts of their substance, nor that the poles of the same name so constantly repel each other; for if a small or weak magnet A have its pole brought near the similar pole of a large or strong magnet B, they are often found to attract when almost touching, although at more considerable distances they repel each other. But this is not an exception to the general proposition; for when the north pole of A is thus attracted by the north pole of B, it will be found, by other trials, to have all the qualities of a south pole, while thus in the neighbourhood of the north pole of B.

The magnetic properties and phenomena are conveniently distinguished into those of FORCE and of POLARITY. Those of the first class only were known to the ancients, and even of them their knowledge was extremely scanty and imperfect. They may all be classed under the following general propositions.

1. The similar poles of two magnets repel each other with a force decreasing as the distances increase. Similar poles repel and dissimilar ... attract each other.

2. The dissimilar poles of two magnets attract each other with a force decreasing as the distances increase.

3. Magnets arrange themselves in a certain determinate position with respect to each other.

The first object of research in our farther examination of these properties is the relation which is observed to obtain between the distances of the acting poles and their force of action. This has accordingly occupied much attention of the philosophers, and numberless experiments have been made in order to ascertain the law of variation, both of the attraction and the repulsion. A great number of these have been narrated in the article MAGNETISM of the *Encycl.* from which it appears that it has been a matter of great difficulty, and had not been ascertained with certainty or precision when that article was published. It is obvious, from the nature of the thing, that the determination is very difficult, and the investigation very complicated. We can only observe the simultaneous motion of the whole magnet; yet we know that there are four separate actions coexisting and contributing in different directions, and with different forces, to the sensible effect. The force which we measure, in any way whatever, is compounded

pounded of four different forces, which we cannot separate and measure apart; for the north pole of A repels the north pole of B, and attracts its south pole, while the south pole of A exerts the opposite forces on the same poles of B. The attraction which we observe is the excess of two unequal attractions above two unequal repulsions. The same might be said of an observed repulsion. Nay, the matter is incomparably more complicated than this; because, for any thing that we know, *every* particle of A acts on *every* particle of B, and is acted on by it; and the intensity of those actions may be different at the same distances, and is certainly different when the distances are so. Thus there is a combination of an unknown number of actions, each of which is unknown individually, both in direction and intensity. The precise determination is therefore, in all probability, impossible. By precise determination, we mean the law of mutual action between two magnetic particles, or that precise function of the distance which defines the intensity of the force; so that measuring the distance of the acting particles on the axis of a curve, the ordinates of the curve may have the proportions of the attractions and repulsions.

It is almost needless to attempt any deduction of the law of variation from the numerous experiments which have been published by different philosophers. An ample collection of them may be seen in Scarella's treatise. Mr Muschenbroek has made a prodigious number; but all are so anomalous, and exhibit such different laws of diminution by an increase of distance, that we may be certain that the experiments have been injudicious. Attention has not been paid to the proper objects. Magnets of most improper shapes have been employed, and of most diffuse polarity. No notice has been taken of a circumstance which, one should think, ought to have occupied the chief attention; namely, the joint action of four poles, of which the experiment exhibits only the complex result. A very slight reflection might have made the enquirer perceive, that the attractions or repulsions are not the most proper phenomena for declaring the precise law of variation; because what we observe is only the excess of a small difference of attractions and repulsions above another small difference. Mr Hawksbee and Dr Brook Taylor employed a much better method, by observing the deviations from the meridian which a magnet occasioned in a compass needle at different distances. This is occasioned by the difference of the two sums of the same forces; and this difference may be made a hundred times greater than the other. But they employed magnets of most improper shapes.

We must except from this criticism the experiments of Mr Lambert, recorded in the Memoirs of the Academy of Berlin for 1756, published in 1758. This most sagacious philosopher (for he highly merits that name) placed a mariner's needle at various distances from a magnet, in the direction of its axis, and observed the declination from the magnetic meridian produced by the magnet, and the obliquity of the magnet to the axis of the needle. Thus, was the action of the magnet set in opposition and equilibrium with the natural polarity of the needle. But the difficulty was to discover in what proportion each of those forces was changed by their obliquity of action on this little lever. No man excelled Mr Lambert in address in devising methods of mathematical investigation. He observed, that when the obliquity of the magnet to the axis of the needle was 30°, it caused it to decline 15°. When the obliquity was 75°, the distance being the same, it declined 30°. Call the obliquity o, and the declination d, and let f be that function of the angle which is proportionable to the action. Also let p be the natural polarity of the needle, and m the force of the magnet. It is evident that

$$p \times f, 15 = m \times f, 30$$

And $p : m = f, 30 : f, 15$; for the same reason

$$p : m = f, 75 : f, 30$$

Therefore $f, 15 : f\, 30 = f, 30 : f, 75$.

But it is well known that

$$\text{Sine } 15 : \text{Sine } 30 = \text{Sine } 30 : \text{Sine } 75.$$

Hence Mr Lambert was led to conjecture, that the sine was that function of the angle which was proportional to the action of magnetism on a lever. But one experiment was insufficient for determining this point. He made a similar comparison of several other obliquities and declinations with the same distances of the magnet, and also with other distances; and he put it past all dispute, that his conjecture was just.

Had Mr Lambert's experiments terminated here, it must be granted that he has made a notable discovery in the theory of the intimate nature of magnetism. It completely refutes all the theories which pretend to explain the action of a magnet by the impulsion of a stream of fluid, or by pressure arising from the motion of such a stream; for in this case the pressure on the needle must have diminished in the duplicate ratio of the sine. The directive power with the angle 90 must be 4 times greater than with the angle 30°; whereas it was observed to be only twice as great. Magnetism does not act therefore by the impulsion or pressure of a stream of fluid, but in the manner of a simple incitement, as we conceive attraction or repulsion to act.

Having ascertained the effect of obliquity, Mr Lambert proceeded to examine the effect of distance; and, by a most ingenious analysis of his observations, he discovered, that if we represent the force of the magnet by f, and the distance of the nearest pole of the magnet from the centre of the needle by z, and if a be a constant quantity, nearly equal to two-thirds of the length of the needle, we have f proportional to $\overline{z-a}^2$.

Mr Lambert found this hold with very great exactness with magnets ten times larger, and needles twice as short. But he acknowledges, that it gives a very singular result, as if the action of a magnet were exerted from a centre beyond itself. He attributes this to its true cause, the still great complication of the result, arising from the action of the remote pole of the magnet. He therefore takes another method of examination, which we shall understand by and bye, when we consider the *directive* power of a magnet. (We have mentioned this imperfect attempt chiefly on account of the unquestionable manner in which he has ascertained the effect of obliquity, and the importance of this determination.

We have attempted this investigation in a very simple manner. We got some magnets made, consisting of two balls connected by a slender rod. By a very particular mode of impregnation, we gave them a pretty good magne-

magnetism; and the force of each pole seemed to reside almost in the centre of the ball. This was our object in giving them this shape. It reduced the examination both of the attractive and of the directive power to a very easy computation. The result was, that the force of each pole varied in the inverse duplicate ratio of the distance. The error of this hypothesis in no case amounted to $\frac{1}{1}$th of the whole. In computing for the phenomena of the directive power, the irregularities and deviations from this ratio were much smaller.

The previous knowledge of this function would greatly expedite and facilitate our farther investigation: but we must content ourselves with a very imperfect approximation, and with arriving at the desired determination by degrees, and by a very circuitous route.

16 mpt plain pheno- a with- a pre- know- e of law.

It is a matter of experience, that when two magnets are taken, each of which is as nearly equal as possible in the strength of both poles, then, if they are placed with their axes in one straight line, and the north pole of one fronting the south pole of the other, they attract each other with a force which diminishes as the distance increases; and this variation of force is regular, that is, without any sudden changes of intensity, till it becomes insensible. No instance has occurred of its breaking suddenly off when of any sensible force; but it appears to diminish continually like gravity. No instance occurs in which attraction is changed into repulsion.

But it is, moreover, to be particularly remarked, that, having made this observation with the north pole of A fronting the south pole of B, if the experiment be repeated with the south pole of A fronting the north pole of B, the results will be precisely the same. And, lastly, it is a matter of unexcepted experience, that the sensible action of A on B, measured by the force which is necessary for preventing the farther approach of B, is precisely equal to the action of B on A. This is the case, however unequal the force of the two magnets may be; that is, although A may support ten pounds of iron, and B only ten ounces.

Now, the simplest view we can take of this experiment is, by supposing the whole action of one end or pole of a magnet to be exerted at one point of it. This will give us four actions of A on B, accompanied by as many equal and opposite actions of B on A. It is plain that we may content ourselves with the investigation of one only of these sets of actions.

What we observe is the excess of the attractions of the poles of A for the dissimilar poles of B above the repulsions of the same poles of A for the similar poles of B. At all distances there is such an excess. The sum of the attractions exceeds the sum of the repulsions competent to every distance.

Now this will really happen, if we suppose that the poles of a magnet are of equal strength, and that, however these different magnets differ in strength, they have the same law of diminution by an increase of distance. The first circumstance is a very possible thing, and the last is demonstrated by the observed equality of action and reaction. Every thing will now appear very plain, by representing (as we did in ELECTRICITY, *Suppl.* nº 44, &c.) the intensities of attraction and repulsion by the ordinates of a curve, of which the abscissæ represent the distances of the acting poles.

Therefore let A and B (fig. 2.) represent the two magnets, placed with their four poles S, N, *s*, *n*, in a straight line. In the straight line O *q* take O *m*, O *p*, O *n*, O *q*, respectively equal to N *s*, N *n*, S *s*, S *n*; and let MPNQ be a curve line, having O *q* for its axis and assymptote; and let the curve, in every part, be convex towards its axis. Then draw the ordinates *m* M, *p* P, *n* N, *q* Q, to the curve. These ordinates will represent the intensities of the forces exerted between the poles of the magnets, in such a manner as to fulfil all the conditions that are really observed: For *m* M represents the attraction of the north pole N of the magnet, A for the south pole *s* of the magnet B; *p* P represents the repulsion of N for *n*; *n* N represents the repulsion of S for *s*; and *q* Q represents the attraction of S for *n*. The distance between *m* and *n*, or between *p* and *q*, is equal to the length of the magnet A, and *m p*, or *n q*, is equal to that of B. M *m*, P *p*, and N *n*, Q *q*, are pairs of equidistant ordinates. It surely requires only the inspection of the figure to see that, in whatever situation along the axis we place those pairs of equidistant ordinates, the sum of M *m* and Q *q* will always exceed the sum of P *p* and N *n*; that is, the sum of the attractions will always exceed that of the repulsions. This will not be the case if the curve, whose ordinates are proportional to the forces, have a point Z of contrary flexure, as is represented by the dotted curve PZQ. For this curve, having O *q* for its assymptote (in order to correspond with forces which diminish continually by an increase of distance, but do not abruptly cease) must have its convexity turned toward this assymptote in the remote parts. But there will be an arch MPZ between Z and O, which is concave toward the assymptote. In which case, it is possible that M *m* + Q *q* shall be less than P *p* + N *n*; and then the repulsions will exceed the attractions; which is contrary to the whole train of observation.

It may be thought, that if the repulsion exerted between two particles be always less than the attraction at the same distance, the phenomena will be accounted for, although the law of action be not represented by such a curve as has been assumed. Undoubtedly they will, while the dissimilar poles front each other. But the results of such a supposition will not agree with the phenomena while the similar poles front each other: For it is an uncontradicted fact, that when two fine hard magnets, whose poles are nearly or exactly of equal vigour, have their similar poles fronting each other, the repulsions fall very little short of the attractions at the same distances when their position is changed. When the distances are considerable, scarcely any difference can be observed in the beginning of the experiment. The differences, also, which are observed at smaller distances, are observed to augment by continuing the magnets in their places without changing their distances; and therefore seem to arise from some change produced by each on the magnetism of the other. And, accordingly, if we invert one of the magnets, we shall find that the attractions have been diminished as much as the repulsions. Now, the consequences of magnetic repulsion, being always weaker than attraction, would be the reverse of this. The differences would appear most remarkable in the greater distances, and magnets might be found which repel at small distances, and attract at greater distances; which is contrary to all observation.

From all this it follows, with sufficient evidence for our

our preſent purpoſe, that the function of the diſtance which expreſſes the law of magnetic action muſt be repreſented by the ordinates of a curve of the hyperbolic kind, referred to its aſſymptote as an axis; and therefore always convex toward this axis. We think it alſo ſufficiently clear, that the conſequences which we have deduced from the ſimple ſuppoſition of four acting points; inſtead of the combined action of every particle, may be adopted with ſafety. For they would be juſt, if there were only thoſe four particles; they would be juſt with reſpect to another four particles—therefore they would be juſt when theſe are joined; and ſo on of any number. Therefore the curve, whoſe ordinates expreſs the mean action of each pole, as if exerted by its centre of effort, will have the ſame general form: It will be convex toward its aſſymptotic axis.

It will greatly aid our conceptions of the combined actions of the four magnetic poles, if we notice ſome of the primary properties of a curve of this kind, limited by no other condition.

17 Unqueſtionable inferences from the phenomena.

Draw the chords MQ, PN, MP, NQ. Biſect them in B, D, E, F, and join EF. Draw the ordinates E e F f, and BD b (cutting EF in C). Draw P u parallel to the axis, cutting E e in r. Draw alſo Q i parallel to the axis, cutting F f in e. Alſo draw FHL parallel to the axis, and P o t parallel to QN; and draw PL l, and P e x, cutting M m in l and x.

Let each ordinate be repreſented by the letter at its interſection with the axis. Thus, the ordinates M m and Q q may be repreſented by m and q, &c.

Becauſe MP is biſected in E, M t is double of E r. M l is double of EL; M x is double of E e. Alſo, becauſe P t is parallel to QN, and P u to Q i, we have $t\,u =$ N i. From theſe premiſes, it is eaſy to perceive, that,

1. $B\,b = \dfrac{m+q}{2}$.
2. $D\,b = \dfrac{p+n}{2}$.
3. $BD = \dfrac{\overline{m+q}-\overline{p+n}}{2}$.
4. $M\,u = m-p$.
5. $u\,t = n-q$.
6. $M\,t = \overline{m-p}-\overline{n-q}$.
7. $E\,e = \dfrac{m+p}{2}$.
8. $F\,f = \dfrac{n+q}{2}$.
9. $M\,l = \overline{m+p}-\overline{n+q}$.
10. $EL = \dfrac{\overline{m+p}-\overline{n+q}}{2}$.
11. $CD = \dfrac{\overline{m+q}-\overline{p+n}}{4}$.
12. $CH = \dfrac{\overline{m+p}-\overline{n+q}}{4}$.

Theſe combinations will ſuggeſt to the attentive reader the explanation of many modifications of the combined action of the four poles of two magnets. They are all comprehended in one propoſition, which it will be convenient to render familiar to the thought; namely, if two pairs of equidiſtant ordinates be taken, the ſum of the two extremes exceeds that of the intermediate ones. $m+q$ is greater than $p+n$. Alſo, the difference between the pair neareſt to O exceeds the difference between the remote pair.

Now, conceiving theſe ordinates to repreſent the mutual actions of the magnetic poles, we ſee that their tendency to or from each other, or their ſenſible attractions or repulſions, are expreſſed by $\overline{m+q}-\overline{n+p}$; that is, by the exceſs of the ſum of the actions of the neareſt and moſt remote poles above the ſum of the actions of the intermediate diſtant poles. It will alſo be frequently convenient to conſider this tendency as repreſented by $\overline{m-p}-\overline{n-q}$; that is, by the exceſs of the difference of the actions of the neareſt pole of A on the two poles of B, above the difference of the actions of its remote pole on the ſame poles of B.

Let us now conſider ſome of the chief modifications of theſe actions.

1. Let the diſſimilar poles front each other. It is plain that $m+q$ repreſent attractions, and that $p+n$ repreſent repulſions. Alſo $m+q$ is greater than $p+n$. Therefore the magnets will attract each other. This attraction is alſo repreſented by $\overline{m-p}-\overline{n-q}$. 18 Explanation of the obſerved attraction of magnets,

Now $\overline{m+q}-\overline{p+n}$ is evidently equal to M t, or to twice E r, or to twice BD, or to four times CD.

This action will be increaſed,

1. By increaſing the ſtrength of either of the magnets. The action of the magnets is the combined action of each acting particle of the one on each acting particle of the other; and it is mutual. Therefore all the ordinates will increaſe in the ratio of the ſtrength of each magnet, and their ſums and differences will increaſe in the ſame ratio.

2. By diminiſhing the diſtance between the magnets. For this brings all the ordinates nearer to D, while their diſtances $m\,p$, $p\,n$, $n\,q$, remain as before. In this caſe it is plain, that M u, the difference of M m and P p, will increaſe faſter than $t\,u$ or N i, the difference between N n and Q q. Therefore M t will increaſe; that is, the attraction will increaſe.

3. By increaſing the length of A, while the diſtance between them remains the ſame. For O m remaining the ſame, as alſo $m\,p$ and $n\,q$, while $n\,q$ is only removed farther from $m\,p$; it is plain M u remains the ſame, and that N i and $t\,u$ are diminiſhed; therefore M t muſt increaſe, or the attraction muſt increaſe.

4. By increaſing the length of B, the diſtance between them remaining the ſame. For this increaſes $m\,p$ and $n\,q$; and conſequently increaſes M u and $t\,u$. But M u increaſes more than $t\,u$; and therefore M t is increaſed, and the attraction or tendency is increaſed.

All theſe conſequences of our original ſuppoſition, that the magnetic action may be repreſented by the ordinates of a curve every where convex to an aſſymptotic axis, are ſtrictly conformable to obſervation.

If we place the magnets with their ſimilar poles fronting each other, it is evident that the ordinates which expreſſed attractions in the former caſe, will now expreſs repulſions; and that the forces with which the magnets now repel each other, are equal to thoſe with which they attracted when at the ſame diſtances. When the experiments are made with good loadſtones, or very fine magnets, tempered extremely hard, and having the energy of their poles ſenſibly reſiding in a ſmall ſpace very near the extremities, the reſults are alſo very nearly 19 And their repulſions.

ly conformable to this mathematical theory; but there is generally a weaker action. The magnets seldom repel as strongly as they attract at the same distance; at least when these distances are small. If one or both of the magnets is soft, or if one of them be much more vigorous than the other, there are observed much greater deviations from this theory. The repulsions are considerably weaker than the attractions at the same distance, and the law of variation becomes extremely different. When placed at very considerable distances, they repel. As the magnet B is brought nearer to A, the repulsion increases, agreeably to the theory, but not so fast. Bringing them still nearer, the repulsion ceases to increase, then gradually diminishes, and frequently vanishes altogether, before the magnets are in contact; and when brought still nearer, it is changed into attraction.

22 ...ung ...prions ...ated. But more careful observation shews, that this anomaly does not invalidate the theory. It is found that the vigour of the magnets is permanently changed by this process. The magnets act on each other in such a way as to weaken each other's magnetism. Nay, it frequently happens, that the weaker or the softer of the two has had its magnetism changed, and that the pole nearest to the other has changed its nature. While they are lying in contact, or at such a distance that they attract, although their similar poles front each other, it is found that the pole of one of them is really changed; although it may sometimes recover its former species again, but never so vigorously as when the other magnet is removed. In short, it is observed, that the magnetism is diminished in all experiments in which the magnets repel each other, and that it is improved in all experiments in which they attract.

We have hitherto supposed the magnets placed with their axes in one straight line. If they are differently placed, we cannot ascertain, by this single circumstance of the law of magnetic action, whether they will attract or repel — we must know somewhat more of the variation of force by a change of distance.

...t ...ctive ...it exerted. If the magnet B be not at liberty to approach toward A, or recede from it, but be so supported at its centre B that it can turn round it, it is very plain that it will retain the position in which it is drawn in the figure. For its south pole s being more attracted by N than it is repelled by S, is, on the whole, attracted by the magnet A; and, by this attraction, it would vibrate like a pendulum that is supported at the centre B. In like manner, its north pole n is more repelled by N than it is attracted by S, and is, on the whole, repelled. The part Bn would therefore also vibrate like a pendulum round B. Thus each half of it is urged into the very position which it now has; and if this position be deranged a little, the attraction of sB toward A, and the repulsion of nB from it, would impel it toward the position sBn.

This will be very evident, if we put the magnet B into the position s'Bn', at right angles to the line AB. The pole s' and the pole n' are urged in opposite, and therefore conspiring, directions with equal forces, very nearly at right angles to $n's$, if the magnet B be small. In any oblique position, the forces will be somewhat unequal, and account must be had of the obliquity of the action, in order to know the precise rotative momentum of the actions.

Dr Gilbert has given to this modification of the action of A on B, the name of VIS DISPONENS; which we may translate by DIRECTIVE POWER OF FORCE. Also, that modification of the tendency of B to or from A is called by him the VERTICITAS of B. We might call it the VERTICITY of B; but we think that the name POLARITY is sufficiently expressive of the phenomenon; and as it has come into general use, we shall abide by it.

It is not so easy to give a general, and at the same time precise, measure of the directive power of A and polarity of B. The magnet B must be considered as a lever; and then the force tending to bring it into its ultimate position ns depends both on the distance of its poles from N and S, and also on the angle which the axis of B makes with the line AB. When the axis of B coincides with AB, the force acting on its poles, tending to keep them in that situation, is evidently $\overline{m+p-n+q}$, and therefore may be represented by Ml (in fig. 2.), or by twice EL, or by four times CH. If B has the position n'Bs', perpendicular to AB, let the ordinates Ee and Ff cut the curve on I and K; and draw KL parallel to the axis (our figure causes this line almost to coincide with QL, and in all important cases it will be nearly the same). In this case IL will express one half of this force. Either of these estimations of this modification of the mutual action of the magnets, will be sufficient for the objects we have in view. 22 Its measure.

The directive power of A, and the polarity of B, are increased, 23 How increased and diminished.

1. By increasing the strength of one or both of the magnets. This is evident,

2. By diminishing the distance of the magnets. For this, by increasing the sum of Mm and Pp more than the sum of Nn and Qq, must increase EL or Ml.

3. By increasing the length of A. For this, by removing n and q farther from m and p, must depress the points L and l, and increase EL, or IL, or Ml.

4. By diminishing the length of B, while the distance Ns between the magnets remains the same. For this, by bringing p and q nearer to m and n, must increase Mm + Pp more than Nn + Qq. Or, by bringing Ee and Ff nearer to Mm and Nn, it must increase EL and Ml.

If the distance Ns between the pole of A and the remote pole of B remain the same, the directive force of A, and polarity of B, are diminished by diminishing the length of B, as is easily seen from what has been just now said. It is also diminished, but in a very small degree, by diminishing the length of B, when the distance between the centres of A and B remain the same. For, in this case, the ordinates Ie and Kf retain their places; but the points m and p approach to e; and this brings the intersection E of the ordinate and chord nearer to I, and diminishes EL, because the point L is not so much depressed by the approach of F to K as E is depressed.

But in all cases, the *ratio* of the directive power of A to its attractive force, or of the polarity of B to its tendency to A, is increased by diminishing the length of B. For it is plain, that by diminishing mp and nq, while Ie and Kf keep their places, the point o is raised, the point L is depressed; and therefore the ratio of EL to Eo, or of Ml to Mt, is increased. We even see that, by diminishing the length of B continually Circumstances ...

and

and without end, the ratio of Ml to Mt may be made to exceed any ratio that can be aſſigned.

25
The polarity of a ſmall magnet may be great while the attraction is inſenſible.

Now, ſince diminiſhing the length of B increaſes the ratio of the directive power of A to its attractive power, while increaſing the length of A increaſes both, and alſo increaſes the ratio of EL to Eo (as is very eaſily ſeen), and ſince this increaſe may be as great as we pleaſe, it neceſſarily follows, that if the ſame very ſmall magnet B be placed at ſuch diſtances from a large and ſtrong magnet A, and from a ſmaller and leſs vigorous one C, as to have equal polarities to both, its tendency to A will be leſs than its tendency to C. It may even be leſs in any ratio we pleaſe, by ſufficiently diminiſhing the length of B.

Dr Gilbert obſerved this; and he expreſſes his obſervation by ſaying, that the directive power extends to greater diſtances than the attracting power. We muſt juſt conclude, that the laſt becomes *inſenſible* at ſmaller diſtances than the firſt. This will be found a very important obſervation. It may be of uſe to keep in mind, that the directive power of a magnet A on another magnet B, is the difference of the *ſums* of the actions of each pole of A on both poles of B; and the attractive power of A for another magnet B, is the difference of the *differences* of theſe actions.

It may be alſo remarked juſt now, that the directive force of A always exceeds its attractive force by the quantity $2\ (p-q)$. For their difference may be expreſſed by tl, which is equal to twice oL. Now ot is equal to Pp, or to p; and oL is equal to Pp — Ff, or to Pp—Qq —Ft, or to Pp—Qq—$o t$. Therefore $o\text{L} = \text{P}p - \text{Q}q$, and $tl = 2\ (\text{P}p - \text{Q}q)$, $= 2\ (p-q)$.

By inſpecting this figure with attention, we obtain indications of many intereſting particulars. If the lengths of the magnets A and B are the ſame, the point n in the axis of the curve will coincide with p. As the length of A increaſes, the part nq is removed farther from the part mp. The line Pt becomes leſs inclined to the axis, and is ultimately parallel to it, when o is infinitely remote. At this time L falls on e; ſo that the ultimate ratio of the attraction to the polarity is that of Ee to Ee, when the magnet A is infinitely long. It is then the ratio of the difference of the actions of the neareſt pole of A on the two poles of B to the ſum of theſe actions. Hence it follows, that when A is very great and B very ſmall, the polarity of B is vaſtly greater than its tendency to A. It may have a great polarity when its tendency is inſenſible.

The ratio of the polarity to the attraction alſo increaſes by increaſing the diſtance of the magnets while their dimenſions continue the ſame. This will appear, by remarking that the chords MP and NQ muſt interſect in ſome point w; and that when the four points m, p, n, and q, move off from O, keeping the ſame diſtances from each other, Eo will diminiſh faſter than EL, and the ratio of EL to EO will continually increaſe.

Therefore when a ſmall magnet B is placed at ſuch a diſtance from a great magnet A, and from a ſmaller one C, as to have equal polarity to both, its tendency to C will exceed its tendency to A. For the polarities being equal, it muſt be farther from the great magnet; in which caſe the ratio of its polarity to its attraction is increaſed.

And this will alſo obtain if the magnets differ alſo in ſtrength. For, to have equal polarities, B muſt be ſtill farther from the great and powerful magnet.

For all theſe reaſons, a large and powerful magnet may exert a ſtrong directive power, while its attractive power is inſenſible.

26
Peculiarities of oblique poſitions of two magnets.

We have hitherto ſuppoſed the magnet B to be placed in the direction of the axis of A, and only at liberty to turn round its centre B. But let its centre be placed on the centre of A, as in fig. 3. it muſt evidently take a poſition which may be called ſubcontrary to that of A, the north pole of B turning toward the ſouth pole of A, and its ſouth pole turning toward the north pole of A.

The ſame thing muſt happen when the centre of B is placed in B, any where in the line AE perpendicular to NS. S attracts n with a force nb, while N repels n with a force nc, ſomewhat ſmaller than nb. Theſe two compoſe the force nd. In like manner, the two forces se and sf, exerted by N and S on the pole s, compoſe the force sq. Now if the axis of the magnet B be parallel to NS, but the poles in a contrary poſition, and if each magnet be equally vigorous in both poles, the magnet B will retain this poſition; becauſe the forces nb and se are equal, as alſo the forces nc and sf. Theſe muſt compoſe two forces nd and sq, which are equal, and equally inclined to ns; and they will therefore be in equilibrio on this lever.

Let us now place the centre of the ſmall magnet in C, neither in the axis of the other, nor in the perpendicular AE. Let its north pole n point toward the centre of A. It cannot remain in this poſition; for N repels n with a force nc, while S attracts it with a force nb (ſmaller than nc, becauſe the diſtance is greater). Theſe two compoſe a force nd conſiderably different from the direction sn of its axis. In like manner, the ſouth pole s of the ſmall magnet is acted on by two forces se and sf, exerted by the two poles of A, which compoſe a force sq nearly equal and parallel to nd, but in a nearly oppoſite direction. It is plain that theſe forces muſt turn the ſmall magnet round its centre C, and that it cannot reſt but in a poſition nearly parallel to nd or sf. Its poſition is better repreſented by fig. 4. with its ſouth pole turned toward the north pole of the other magnet, and its north pole in the oppoſite direction.

What the preciſe poſition will be, depends on that function of the diſtance which is always proportional to the intenſity of the action; on the force of each of the poles of A, and on the length of the magnet B. Nay, even when we know this function, the problem is ſtill very intricate.

27
Means of acquiring a near meaſure of the law of action.

There are methods by which we may approximate to the function with ſucceſs. If the magnet B be indefinitely ſmall, ſo that we may conſider the actions on its two poles as equal, the inveſtigation is greatly ſimplified. For, in this caſe, each pole of the ſmall magnet B (fig. 5.) may be conceived as coinciding with its centre. Then, drawing NB, SB, and taking Bb toward N, to repreſent the force with which N attracts the ſouth pole of B, and taking Bc, in SB produced, to repreſent the force with which S repels the ſame pole, the compound force acting on this pole is Bd; the diagonal of a parallelogram Bb, dc. In like manner, we muſt take Be, in Nb produced, and equal to Bb,

to

to represent the repulsion of N for the north pole of B, and B f equal to B c, to represent the attraction of S for this pole. The compound force will be B g, equal and opposite to B d. It follows evidently from this investigation, that the small magnet will not rest in any position but $d g$. In this supposition, therefore, of extreme minuteness of the magnet B, one of the parallelograms is sufficient. We may farther remark, that we have this approximation secure against any error arising from the supposition that all the action of each pole of B is exerted by one point. Although we suppose it diffused over a considerable portion of the magnet, still the extreme minuteness of the whole makes the action, even on its extreme points, very nearly equal.

28 Hence may be derived a construction for ascertaining the position of the needle, when the function m of the distance is given, or for discovering this function by observation of the position of the needle.

Let NS (fig. 5. n° 2.) meet the direction of the needle in K. Make BG = BN, and draw NF, GE, SH, perpendicular to BK. It is evident that B b is to B c, or b d, as the sine of the angle HBS to the sine of KBN. Therefore, because BG and BN are equal, we have B b : B c = GE : NF.

Therefore GE : NF = BS^m : BN^m

But SH : GE = BS : BN

Therefore SH : NF = BS^{m+1} : BN^{m+1}

And SK : NK = BS^{m+1} : BN^{m+1}

If magnetic action be inversely as the distance, we have SK : NK = BS^2 : BN^2, and B is in the circumference of a circle which passes through S and N, and has BK for a tangent, as is plain by elementary geometry. If the action be inversely as the square of the distance, we have SK : NK = BS^3 : BN^3, and B is in the circumference of a curve of more difficult investigation. But, as in the circle, the sum of the angles BSN and BNS is a constant angle, so, in this curve, the sum of the cosines of those angles is a constant quantity. This suggests a very simple construction of the curve. Let it pass through the point T of the line AT, drawn from the centre of the magnet, perpendicular to its axis. Describe the semicircle SPQN, cutting ST and NT in P and Q. Then, in order to find the point where any line SB cuts the curve, let it cut the semicircle in p, and apply the line N q = SP + NQ — S p, and produce it till it meet the line SB in B, which is a point in the curve; for it is evident that S p and N q are the cosines of BSN and BNS. We hope to give, by the help of a learned friend, the complete construction of curves for every value of m, in an Appendix to this article. It will form a new and curious class, arranged by the functions of the angles at N and S.

But, in the mean time, we have determined the position of an indefinitely small needle, in respect of a magnet of which we may conceive the polar activity concentrated in two points; and we may, on the other hand, make use of the observed positions of such a needle and magnet for discovering the value of m. For, since $\frac{SK}{NK}=\frac{SB^{m+1}}{NB^{m+1}}$, it is plain that $m=\frac{\text{Log. SK : NK}}{\text{Log. SB : NB}}-1$. Thus, in an observation which the writer of this article made on a very small needle, and a magnet having globular poles, and $8\frac{1}{3}$ inches between their centres, he found SB = $5\frac{1}{3}$, NB = $\frac{1}{4}$, SK = 11,49, and NK = 3,37. This gives m = 1,97, which differs from 2 only $\frac{1}{33}$th part. Finding it so very near the inverse duplicate ratio of the distance, a circle VUZ was described, the circumference of which is the locus of SB : BN = 8 : 5,333. When the centre of the needle was placed anywhere in the circumference of this circle, it scarcely deviated from the point K, except when so far removed from the magnet that its natural polarity prevailed over the directive power of the magnet, or so near its middle that the action of the cylindrical part became very sensible.

It is plain that the length of the needle must occasion some deviation from the magnetic direction, by destroying the perfect equality of action on its two poles. He therefore employed three needles of $\frac{1}{4}$, $\frac{1}{7}$, and $\frac{1}{2}$ of an inch in length; and by noticing the differences of direction, he inferred what would be the direction, if the forces on each pole were precisely equal. He had the pleasure of seeing that the deviation from the inverse duplicate ratio of the distances was scarcely perceptible.

Mr Lambert's experiments on the directive power of the magnet, narrated in his second dissertation in the 22d volume of the Memoirs of the Academy of Berlin, are the most valuable of all that are on record; and the ingenious address with which they are conducted, and the inferences are drawn, would have done credit to Newton himself. We earnestly recommend the careful perusal of that Essay, as the most instructive of any that we have read. The writer of this found himself obliged to repeat all his former experiments, mentioned above, in Mr Lambert's manner, and with his precaution of keeping the needle in its natural position; a circumstance to which he had not sufficiently attended before. The new results were still more conformable to his conjecture as to the law of variation. Mr Lambert closes his dissertation with an hypothesis, "that the force of each transverse element of a magnet is as its distance from the centre, and its action on a particle of another magnet is inversely as the square of the distance." On this supposition, he calculates the position of a very small needle, and draws three of the curves to which it should be the tangent. These are very exactly coincident with some that he observed. We tried this with several magnetic bars, and found it very conformable to observation in some magnets; but deviating so far in the case of other magnets, that we are convinced that there is no rule for the force of each transverse element of a magnet, and that the magnetism is differently disposed in different magnets. It was chiefly this which induced us to form the magnets employed in this research of two balls united by a slender rod. Lichtenberg, in his notes on Erxleben's Natural Philosophy, says, that there is a MS. of the celebrated Tobias Mayer in the library of the Academy of Gottingen, in which he assumes the hypothesis above-mentioned, and gives a construction of the magnetic curves founded on it, making them a kind of catenaria. The interior curves do indeed resemble the catenaria, but the exterior are totally unlike. But there is no occasion for much argument to convince us, that the first part of this hypothesis is not only gratuitous, but unwarranted by any general phenomena. We know that a magnetical bar may have its magnetism very differently disposed; for it may have more than two poles, and the intermediate poles *cannot* have this disposition of the magnetism.

netism. Such a disposition is perhaps possible; but is by no means general, or even frequent. We are disposed to think, that permanent magnetism must have its intensity diminishing in the very extremity of the bar. The reader may guess at our reasons from what is said in ELECTRICITY, *Suppl.* n° 222.

The following very curious and instructive phenomenon was the first thing which greatly excited the curiosity of the writer of this article, and long puzzled him to explain it. Indeed it was his endeavours to explain it which gradually opened up to him the theory of the mutual action of magnets contained in these paragraphs, and first gave him occasion to admire the sagacity of Dr Gilbert, and to see the connecting principle of the vast variety of observations and experiments which that philosopher had made. It seems owing to the want of this connecting principle, that a book so rich in facts should be so little read, and that so many of Dr Gilbert's observations have been published by others as new discoveries.

Amusing himself in the summer 1758 with magnetic experiments, two large and strong magnets A and B (fig. 6), were placed with their dissimilar poles fronting each other, and about three inches apart. A small needle, supported on a point, was placed between them at D, and it arranged itself in the same manner as the great magnets. Happening to set it off to a good distance on the table, as at F, he was surprised to see it immediately turn round on its pivot, and arrange itself nearly in the opposite direction. Bringing it back to D restored it to its former position. Carrying it gradually out along DF, perpendicular to NS, he observed it to become sensibly more feeble, vibrating more slowly; and when in a certain point E, it had no polarity whatever towards A and B, but retained any position that was given it. Carrying it farther out, it again acquired polarity to A and B, but in the opposite direction; for it now arranged itself in a position that was parallel to NS, but its north pole was next to N, and its south pole to S.

This singular appearance naturally excited his attention. The line on which the magnets A and B were placed had been marked on the table, as also the line DF perpendicular to the former. The point E was now marked as an important one. The experiments were interrupted by a friend coming in, to whom such things were no entertainment. Next day, wishing to repeat them to some friends, the magnets A and B were again laid on the line on which they had been placed the day before, and the needle was placed at E, expecting it to be neutral. But it was found to have a considerable verticity, turning its north pole toward the magnet B; and it required to be taken farther out, toward F, before it became neutral. While standing there, something chanced to joggle the magnets A and B, and they instantly rushed together. At the same instant, the little magnet or needle turned itself briskly, and arranged itself, as it had done the day before, at F, quivering very briskly, and thus shewing great verticity. This naturally surprised the beholders; and we now found that, by gradually withdrawing the magnets A and B from each other, the needle became weaker—then became neutral—and then turned round on its pivot, and took the contrary position. It was very amusing to observe how the simply separating the magnets A and B, or bringing them together, made the needle assume such a variety of positions and degrees of vivacity in each.

The needle was now put in various situations, in respect to the two great magnets; namely, off at a side, and not in the perpendicular DF. In these situations, it took an inconceivable variety of positions, which could not be reduced to any rule; and in most of them, it required only a motion of one of the great magnets for an inch or two, to make the needle turn briskly round on its pivot, and assume a position nearly opposite to what it had before.

But all this was very puzzling, and it was not till after several months, that the writer of this article, having conceived the notion of the magnetic curves, was in a condition to explain the phenomena. With this assistance, however, they are very clear, and very instructive.

Nothing hinders us from supposing the magnets A and B perfectly equal in every respect. Let NHM, NEL, be two magnetic curves belonging to A; that is, such that the needle arranges itself along the tangent of the curve. Then the magnet B has two curves SGK, SEI, perfectly equal, and similar to the other two. Let the curves NHM and SGK intersect in C and F. Let the curves NEL and SEI touch each other in E.

The needle being placed at C, would arrange itself in the tangent of the curve KGS, by the action of B alone, having its north pole turned toward the south pole S of B. But, by the action of A alone, it would be a tangent to the curve NHM, having its north pole turned away from N. Therefore, by the combined action of both magnets, it will take neither of these positions, but an intermediate one, nearly bisecting the angle formed by the two curves, having its north pole turned toward B.

But remove the needle to F. Then, by the action of the magnet A, it would be a tangent to the curve FM, having its north pole toward M. By the action of B, it would be a tangent to the curve KFG, having its north pole in the angle MFG, or turned toward A. By their joint action, it takes a position nearly bisecting the angle GFM, with its north pole toward A.

Let the needle be placed in E. Then, by the action of the magnet A, it would be a tangent to the curve NEL, with its north pole pointing to F. But, by the action of B, it will be a tangent to SEI, with its north pole pointing to D. These actions being supposed equal and opposite, it will have no verticity, or will be neutral, and retain any position that is given to it.

The curve SEI intersects the curve NHM in P and Q. The same reasoning shews, that when the needle is placed at P, it will arrange itself with its north pole on the angle SPH: but, when taken to Q, it will stand with its north pole in the angle EQM.

From these facts and reasonings we must infer, that, for every distance of the magnets A and B, there will be a series of curves, to which the indefinitely short needle will always be a tangent. They will rise from the adjoining poles on both sides, crossing diagonally the lozenges formed by the PRIMARY or SIMPLE curves, as in fig. 6. These may be called COMPOUND or SECONDARY magnetic curves. Moreover, these secondary

condary curves will be of two kinds, according as they pass through the first or second intersections of the primary curves and the needle will have opposite positions when placed on them. These two sets of curves will be separated by a curve GEH, in the circumference of which the needle will be neutral. This curve passes through the points where the primary curves touch each other. We may call this the *line of neutrality* or inactivity.

We now see distinctly the effect of bringing the magnets A and B nearer together, or separating them farther from each other. By bringing them nearer to each other, the point E, which is now a point of neutrality, may be found in the *second* intersection (such as F) of two magnetic curves, and the needle will take a subcontrary position. By drawing them farther from each other, E may be in the *first* intersection of two magnetic curves, and the needle will take a position similar to that of C.

If the magnets A and B are not placed so as to form a straight line with their four poles, but have their axes making an angle with each other, the contacts and intersections of their attending curves may be very different from those now represented; and the positions of the needle will differ accordingly. But it is plain, from what has been said, that if we knew the law of action, and consequently the form of the primary curves, we should always be able to say what will be the position of the needle. Indeed, the consideration of the simple curves, although it was the mean of suggesting to the writer of this article the explanation of those more complicated phenomena, is by no means necessary for this purpose. Having the law of magnetic action, we must know each of the eight forces by which the needle is affected, both in respect of direction and intensity; and are therefore able to ascertain the single force arising from their composition.

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When the similar poles of A and B are opposed to each other, it is easy to see, that the position of the needle must be extremely different from what we have been describing. When placed anywhere in the line DF, between two magnets, whose north poles front each other in N and S, its north pole will always point away from the middle point D. There will be no neutral point E. If the needle be placed at P or Q, its north pole will be within the angle EPH, or FQI. This position of the magnets gives another set of secondary curves, which also cross the primary curves, passing diagonally through the lozenges formed by their intersection. But it is the other diagonal of each lozenge which is a chord to those secondary curves. They will, therefore, have a form totally different from the former species.

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The consideration of this compounded magnetism is important in the science, both for explaining complex phenomena, and for advancing our knowledge of the great desideratum, the law of magnetic action. It serves this purpose remarkably. By employing a very small needle, the points of neutrality ascertain very nearly where the magnetic curves have a common tangent, and shews the position of this tangent. By placing the two magnets so as to form various angles with each other, we can, by means of these neutral points, know the position of the tangent in every point of the curve, and thus can ascertain the form of the curve, and the law of action, with considerable accuracy. The writer of this article took this method; and the result confirmed him in the opinion, that it was in the inverse duplicate ratio of the distances. The chief (perhaps the only) ground of error seemed to be the difficulty of procuring large magnets, having the action of each pole very much concentrated. Large magnets must be employed. He attempted to make such, consisting of two spherical balls, joined by a slender rod. But he could not give a strong magnetism to magnets of this form, and was forced to make use of common bars, the poles of which are considerably diffused. This diffusion of the pole renders it very difficult to select with propriety the points from which the distances are to be estimated, in the investigation of the relation between the forces and distances.

He tried another method for ascertaining this so much desired law, which had also the same result. Having made a needle consisting of two balls joined by a slender rod, and having touched it with great care, so that the whole strength of its poles seemed very little removed from the centres of the balls, he counted the number of horizontal vibrations which it made in a given time by the force of terrestrial magnetism. He then placed it on the middle of a very fine and large magnet, placed with its poles in the magnetic meridian, the north pole pointing south. In this situation he counted the vibrations made in a given time. He then raised it up above the centre of the large magnet, till the distance of its poles from those of the great magnet were changed in a certain proportion. In this situation its vibrations were again counted. It was tried in the same way in a third situation, considerably more remote from the great magnet. Then, having made the proper reduction of the forces corresponding to the obliquity of their action, the force of the poles of the great magnet was computed from the number of vibrations. To state here the circumstances of the experiment, the necessary reductions, and the whole computations, would occupy several pages, and to an intelligent reader would answer little purpose. Mr Lambert's excellent dissertation in the 22d vol. of the *Mem. de l'Acad. de Berlin*, will shew the prolixity and intricacy of this investigation. Suffice it to say, that these experiments were the most consistent with each other of any made by the writer of this article, with the view of ascertaining the law of magnetic action; and it is chiefly from their result that he thinks himself authorised to say, with some confidence, that it is inversely as the square of the distance. These experiments were first made in a rough way in 1769 and 1772. In 1775, observing that Mr Æpinus seemed to think the action inversely as the distance (see his *Tentam. Theor. Electr. et Magn.* § 301. &c.), they were repeated with very great care; and to these were added another set of experiments, made with the same magnet and the same needle, placed not above the magnet, but at one side (but always in the line through the centre, perpendicular to the axis, so that the actions of the two poles might be equal). This disposition evidently simplifies the process exceedingly. The result of the whole was still more satisfactory. This conclusion is also confirmed by the experiments of Mr Coulomb in the Memoirs of the Academy of Sciences at Paris for 1786 and 1787. It would seem therefore to be pretty well established. Another method, which seems susceptible of

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confiderable accuracy, ftill remains to be tried. It will be mentioned in due time.

Such then are the general laws obferved in the mutual action of magnets. We think it fcarcely neceffary to enter into a farther detail of their confequences, correfponding to the innumerable varieties of pofitions in which they may be placed with refpect to each other. We are confident, that the fenfible actions will always be found agreeable to the legitimate confequences of the general propofitions which we have eftablifhed in the preceding paragraphs. We proceed therefore to confider fome phyfical facts not yet taken notice of, which have great influence on the phenomena, and greatly affift us in our endeavours to underftand fomething of their remote caufe.

31 ...netifm ...mpora... pe- Magnetifm, in all its modifications of attraction, repulfion, and direction, is, in general, of a temporary or perifhing nature. The beft loadftones and magnets, unlefs kept with care, and with attention to certain circumftances, are obferved to diminifh in their power. Natural loadftones, and magnets made of fteel, tempered as hard as poffible, retain their virtue with greateft obftinacy, and feldom lofe it altogether, unlefs in fituations which our knowledge of magnetifm teaches us to be unfavourable to its durability. Magnets of tempered fteel, fuch as is ufed for watch-fprings, are much fooner weakened, part with a greater proportion of their force by fimple keeping, and finally retain little or none. Soft fteel and iron lofe their magnetifm almoft as foon as its producing caufe is removed, and cannot be made to retain any fenfible portion of it, unlefs their metallic ftate fuffer fome change.

1. Nothing tends fo much to impair the power of a magnet as the keeping it in an improper pofition. If its axis be placed in the magnetic direction, but in a contrary pofition, that is, with the north pole of it where the fouth pole tends to fettle, it will grow weaker from day to day; and unlefs it be a natural loadftone, or be of hard tempered fteel, it will, after no very long time, lofe its power altogether.

2. This diffipation of a ftrong magnetic power is greatly promoted by heat. Even the heat of boiling water affects it fenfibly; and if it be made red hot, it is entirely deftroyed. This laft fact has long been known. Dr Gilbert tried it with many degrees of violent heat, and found the confequences as now ftated; but having no thermometers in that dawn of fcience, he could not fay any thing precife. He only obferves, that it is deftroyed by a heat not fufficient to make it vifible in a dark room. Mr Canton found even boiling water to weaken it; but on cooling again the greateft part was recovered.

3. What is more remarkable, magnetifm is impaired by any rough ufage. Dr Gilbert found, that a magnet which he had impregnated very ftrongly, was very much impaired by a fingle fall on the floor; and it has been obferved fince his time, that falling on ftones, or receiving any concuffion which caufes the magnet to ring or found, hurts it much more than beating it with any thing foft and yielding. Grinding a natural loadftone with coarfe powders, to bring it into fhape, weakens it much; and loadftones fhould therefore be reduced into a fhape as little different from their natural form as poffible; and this fhould be done brifkly, cutting them with the thin difks of the lapidary's wheel, cutting off only what is neceffary for leaving their moft active parts or poles as near their extremities as we can.

All thefe caufes of the diminution of magnetifm are more operative if the magnet be all the while in an improper pofition.

4. Laftly, magnetifm is impaired and deftroyed by placing the magnet near another magnet, with their fimilar poles fronting each other. We have had occafion to remark this already, when mentioning the experiments made with magnets in this pofition, for afcertaining the general laws or variations of their repulfion. We there obferved, that magnets fo fituated always weakened each other, and that a powerful magnet often changed the fpecies of the neareft pole of one lefs powerful. This change is recovered, in part at leaft, when it has taken place in a loadftone or a magnet of hard fteel; but in fpring tempered fteel the change is generally permanent; and almoft to the full extent of its condition while the magnets are together. It is to be remarked, that this change is gradual; and is expedited by any of the other caufes, particularly by heat or by knocking. 4. By other magnets.

32 Magnetifm may be acquired,

On the other hand, magnetifm is acquired by the fame means, when fome other circumftances are attended to:

1. By magnetical pofition; 1. A bar of iron, which has long ftood in the magnetic direction, or nearly fo, will gradually acquire magnetifm, and the ends will acquire the polarity correfponding to their fituation. In this country, and the north of Europe, the old fpindles of torret vanes, old bars of windows, &c. acquire a fenfible magnetifm; their lower extremity becoming a north pole, and the other end a fouth pole. Gilbert fays, that this was firft obferved in Mantua, in the vane fpindle of the Auguftine church—"*Venia flexa* (fays he) *de prompta, et apothecario cuidam conceffa, attrahebat ferrea ramenta, vel perquam infignis.*" The upper bar of a hand rail to a ftair on the north fide of the higheft part of the fteeple of St Giles's church in Edinburgh is very magnetical; and the upper end of it, where it is lodged in the ftone, is a vigorous fouth pole. It is worth notice, that the parts of fuch old bars acquire the ftrongeft magnetifm when their metallic ftate is changed by expofure to the air, becoming foliated and friable. It would be worth while to try, whether the æthiops martialis, produced by fteam in the experiments for decompofing water, will acquire magnetifm during its production. The pipe and the wires, which are converted into the fhining æthiops, fhould be placed in the magnetic direction.

2. By hammering; 2. If a bar of fteel be long hammered while lying in the magnetic direction, it acquires a fenfible magnetifm (See Dr Gibert's plate, reprefenting a blackfmith hammering a bar of iron in the magnetic direction). The points of drills, efpecially the great ones, which are urged by very great preffure; and broaches, worked by a long lever, fo as to cut the iron very faft, acquire a ftrong magnetifm, and the lower end always becomes the north pole (*Phil. Tranf.* xx 417.) Even driving a hard fteel punch into a piece of iron, gives it magnetifm by a fingle blow. In fhort, any very violent fqueeze given to a piece of tempered fteel renders it magnetic, and its polarity correfponds with its pofition during the experiment. We can fcarcely take up a cutting or boring tool in a fmith's fhop that is not magnetical. Even

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soft steel and iron acquire permanent magnetism in this way. Iron also acquires it by twisting and breaking. It is therefore difficult to procure pieces of iron or steel totally void of determinate and permanent magnetism; and this frequently mars the experiments mentioned in the first paragraphs of this article. The way therefore to ensure success in these experiments is to deprive the rods of their accidental magnetism, by some of the methods mentioned a little ago. Let them be heated red hot, and allowed to cool while lying in a direction perpendicular to the magnetic direction (nearly E. N. E. and W. S. W. in this country).

y heat. 3. As heat is observed to destroy magnetism, so it may also be employed to induce it on substances that are susceptible of magnetism. Dr Gilbert makes this observation in many parts of his work. He says, that the ores of iron which are in that particular metallic state which he considers as most susceptible of magnetism, will acquire it by long continuance in a red heat, if laid in the magnetic direction, and that their polarity is conformable to their position, that end of the mass which is next the north becoming the north pole. He also made many experiments on iron and steel bars exposed to strong heats in the magnetical direction. Such experiments have been made since Gilbert's time in great number. Dr Hooke, in 1684, made experiments on rods of iron and steel one fifth of an inch in diameter, and seven inches long. He found them to acquire permanent magnetism by exposure to strong heat in the magnetic direction, and if allowed to cool in that direction. But the magnetism thus acquired by steel rods was much stronger, and more permanent, if they were suddenly quenched with cold water, so as to temper them very hard. He found, that the end which was next to the north, or the lower end of a vertical bar, was always its permanent north pole. Even quenching the upper end, while the rest was suffered to cool gradually, became a very sensible south pole. No magnetism was acquired if this operation was performed on a rod lying at right angles to the magnetical direction.

In these trials the polarity was always estimated by the action on a mariner's needle, and the intensity of the magnetism was estimated by the deviation caused in this needle from its natural position. Dr Gilbert made a very remarkable observation, which has since been repeated by Mr Cavallo, and published in the Philosophical Transactions as a remarkable discovery. Dr Gilbert says, p. 69. "*Bacillum ferreum, valide ignitum appone versorio excito; stat versorium, nec ad tale ferrum convertitur: sed statim ut primum de candore aliquantulum remiserit, confluit illico.*" In several other parts of his treatise he repeats the same thing with different circumstances. It appears, therefore, that while iron is red hot, it is not susceptible of magnetism, and that it is during the cooling in the magnetic direction that it acquires it. Gilbert endeavoured to mark the degree of heat most favourable for this purpose; but being unprovided with thermometers, he could not determine any thing with precision. He says, that the versorium, or mariner's needle, was most deranged from its natural position a little while after the bar of iron ceased to shine in day-light, but was still pretty bright in a dark room. But there are other experiments which we have made, and which will be mentioned by and bye; by which it appears, that although a bright red or a white heat makes iron unsusceptible of magnetism while in that state, it predisposes it for becoming magnetical. When a bar of steel was made to acquire magnetism by tempering it in the magnetical direction, we found that the acquired magnetism was much stronger when the bar was made first of all very hot, even although allowed to come to its most magnetical state before quenching, than if it had been heated only to that degree; nay, we always found it stronger when it was quenched when red hot. We offer no explanation at present; our sole business just now being to state facts, and to generalize them, in the hopes of finding some fact which shall contain all the others.

4. The most distinct acquisitions and changes of magnetism are by juxtaposition to other magnets and to iron. 4. As the magnetism of a loadstone or magnet is weakened by bringing its pole near the similar pole of another magnet, it is improved by bringing it near the other pole; and it is always improved by bringing it near any piece of iron or soft steel.

But this action, and the mutual relation of magnets and common iron, being the most general, and the most curious and instructive of all the phenomena of magnetism, they merit a very particular consideration.

Of the communication of Magnetism.

The whole may be comprehended in one proposition, which may be said to contain a complete theory of magnetism. 33 Communication of magnetism.

Fundamental proposition.

Any piece of iron, when in the neighbourhood of a magnet, is a magnet, and its polarity is so disposed that the magnet and it mutually attract each other.

The phenomena which result from this fundamental principle are infinitely various, and we must content ourselves with describing a simple case or two, which will sufficiently enable the reader to explain every other.

Take a large and strong magnet NAS (fig. 7.), of which N is the north, and S the south pole. Let it be properly supported in a horizontal position, with its poles free, and at a distance from iron or other bodies. 34 Operative powers illustrated. Take any small piece of common iron, not exceeding two or three inches in length, such as a small key. Take also another piece of iron, such as another smaller key, or a bit of wire about the thickness of an ordinary quill.

1. Hold the key horizontally, near one of the poles, (as shewn at n° 1.), taking care not to touch the pole with it; and then bring the other piece of iron to the other end of the key (it is indifferent which pole is thus approached with the key, and which end of the key is held near the pole). The wire will hang by the key, and will continue to hang by it, when we gradually withdraw the key horizontally from the magnet, till, at a certain distance, the wire will drop from the key, because the magnetism imparted from this distance is too weak. That this is the sole reason of its dropping, will appear by taking a shorter, or rather a slenderer, bit of wire, and touch the remote end of the key with it: it will be supported, even though we remove the key still farther from the magnet.

2. Hold the key *below* one of the poles, as at n° 2. or 3. and touch its remote end with the wire. It will be suspended in like manner, till we remove the key too far from the magnet.

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3. Hold the key *above* the poles, as at nº 4. or 5. and touch its adjacent end with the wire (taking care that the wire do not alſo touch the magnet). The wire will ſtill be ſupported by the key, till both are removed too far from the magnet.

Thus it appears, that in all theſe ſituations the key has ſhewn the characteriſtic phenomenon of magnetiſm, namely, attraction for iron. In the experiment with the key held above the pole, the wire is in the ſame ſituation in reſpect to magnetiſm as the key is when held below the pole; but the actions are mutual. As the key attracts the wire, ſo the wire attracts the key.

If the magnet be ſupported in a vertical poſition, as in fig. 8. the phenomena will be the ſame; and when the key is held directly above or directly below the pole, it will carry rather a heavier wire than in the horizontal poſition of the magnet and key.

Inſtead of approaching the magnet with the key and wire, we may bring the magnet toward them, and the phenomena will be ſtill more palpable. Thus, if the bit of wire be lying on the table, and we touch one end of it with the key, they will ſhew no connection whatever. While we hold the key very near one end of the wire, bring down the pole of a magnet toward the key, and we ſhall then ſee the end of the wire riſe up and ſtick to the key, which will now ſupport it. In like manner, if we lay a quantity of iron filings on the table, and touch them with the key, in the abſence of the magnet, we find the key totally inactive. But, on bringing the magnet anyhow near the key, it immediately attracts the iron filings, and gathers up a heap of them.

In the next place, this vicinity of a magnet to a piece of iron gives it a directive power. Let NAS (fig. 9.) be a magnet, and BC (nº 1.) a key held near the north pole, and in the direction of the axis. Bring a very ſmall mariner's needle, ſupported on a ſharp point, near the end C of the key which is fartheſt from N. We ſhall ſee this needle immediately turn its ſouth pole towards C, and its north pole away from C. This poſition of the needle is indicated at *c*, by marking its north pole with a dart, and its ſouth with a croſs. Thus it appears that the key has got a directive power like a magnet, and that the end C is performing the office of a north pole, attracting the ſouth pole of the needle, and repelling its north pole. It may indeed be ſaid, that the needle at *c* arranges itſelf in this manner by the directive power of the magnet; for it would take the ſame poſition although the key were away. But if we place the needle at *b*, it will arrange itſelf as there repreſented, ſhewing that it is influenced by the key, and not (wholly at leaſt) by the magnet. In like manner, if we place the needle at *a*, we ſhall ſee it turn its north pole toward B, notwithſtanding the action of the magnet on it. This action evidently tends to turn its north pole quite another way; but it is influenced by B, and B is performing the office of a ſouth pole.

In like manner, it we place the key as at nº 2. we ſhall obſerve the end B attract the ſouth pole of the needle placed at *a*, and the end C attract the north pole of a needle placed in *b*. In this ſituation of the key, we ſee that B performs the office of a north pole, and C performs the office of a ſouth pole.

Thus it appears that the key in both ſituations has become a magnet, poſſeſſed of both an attractive and a directive power. It has acquired two poles.

Laſtly, the magnetiſm of the key is ſo diſpoſed, that the two magnets NAS and BC muſt mutually attract each other; for their diſſimilar poles front each other. Now, it is a matter of uniform and uncontradicted obſervation, that when a piece of iron is thus placed near a magnet, and the diſpoſition of its magnetiſm is thus examined by means of a mariner's needle, the diſpoſition is ſuch that two permanent magnets with their poles ſo diſpoſed muſt attract each other. The piece of iron, therefore, having the ſame magnetic relation to the magnet that a ſimilar and ſimilarly diſpoſed magnet has, muſt be affected in the ſame manner. We cannot, by any knowledge yet contained in this article, give any preciſe intimation in what way the polarity of the piece of iron will be diſpoſed. This depends on its ſhape as much as on its poſition. By deſcribing two or three examples, a notion is obviouſly enough ſuggeſted, which, although extremely gratuitous, and perhaps erroneous, is of ſervice, becauſe it has a general analogy with the obſerved appearances.

The attraction of iron is owing to the diſpoſition of its own temporary magnetiſm.

If one end of a ſlender rod or wire be held near the north pole of the magnet, while the rod is held in the direction of the axis (like the key in fig. 7. nº 1.), the near end becomes a ſouth, and the remote end a north pole. Keeping this ſouth pole in its place, and turning the rod in any direction from thence, as from a centre, the remote end is always a north pole. And, in general, the end of any oblong piece of iron which is neareſt to the pole of a magnet becomes a pole of the oppoſite name, while the remote end becomes a pole of the ſame name with that of the magnet.

If the iron rod be held perpendicularly to the axis, with its middle very near the north pole of the magnet, the two extremities of the iron become north poles, and the middle is a ſouth pole.

If the north pole of a magnet be held perpendicular to the centre of a round iron plate, and very near it, this plate will have a ſouth pole in its centre, and every part of its circumference will have the virtue of a north pole.

If the plate be ſhaped with points like a ſtar, each of theſe points will be a very diſtinct and vigorous north pole.

Something like this will be obſerved in a piece of iron of any irregular ſhape. The part immediately adjoining to the north pole of the magnet will have the virtue of a ſouth pole, and all the remote protuberances will be north poles.

The notion naturally ſuggeſted by theſe appearances is, that the virtue of a north pole ſeems to reſide in ſomething that is moveable, and that is protruded by the north pole of the magnet toward the remote parts of the iron; and is thus conſtipated in all the remote edges, points, and protuberances, much in the ſame manner as electricity is obſerved to be protruded to the remote parts and protuberances of a conducting body by the preſence of an overcharged body. This notion will greatly aſſiſt the imagination; and its conſequences very much reſemble what we obſerve.

As a farther mark of the complete communication of every magnetic power by mere vicinity to a magnet, we may here obſerve, that the wire D, of fig. 7. nº 2. and 3. will ſupport another wire, and this another; and ſo on,

on, to a number depending on the ſtrength of the magnet. The key has therefore become a true magnet in every reſpect; for it induces complete magnetiſm on the appended wire. That this is not the ſame operation of the great magnet (at leaſt not wholly ſo), appears by examining the magnetiſm of D with the needle, which will be ſeen to be more influenced by D than by A. This fact has been long known. The ancients ſpeak of it: They obſerve, that a loadſtone cauſes an iron ring to carry another ring, and that a third; and ſo on, till the ſtring of rings appears like a chain.

37 ception plained.

What has now been ſaid will explain a ſeeming exception to the univerſality of the propoſition. If the key be held in the ſituation and poſition repreſented by fig. 10. the bit of wire will not be attracted by it; and we may imagine that it has acquired no magnetiſm: But if we bring a mariner's needle, or a bit of wire, near to its remote end B, it will be ſtrongly attracted, and ſhew B to be a north pole. The needle held near to C will alſo ſhew C to be a ſouth pole. Alſo, if held near to D, it will ſhew D to be a north pole. Now the ends C, both of the key and of the wire, being ſouth poles, they cannot attract each other, but, on the contrary, they will repel; and therefore the wire will not adhere to the key. And if the key of fig. 17. n° 4. with the wire hanging to it, be gradually carried outward, beyond the north pole of the magnet, and then brought down till its lower end be level with the pole, the wire will drop off.

There is, however, one exception to the propoſition. If the key in fig. 7. with its appending wire D, be gradually carried from any of the ſituations 3, 4, or 5, toward the middle of the magnet, the wire will drop off whenever it arrives very near the middle. If we ſuppoſe a plane to paſs through the magnetic centre A, perpendicular to the axis (which plane is very properly called the magnetic equatorial plane by Gilbert), a ſlender piece of iron, held any where in this plane, acquires no ſenſible magnetiſm. It gives no indication of any polarity, *and it is not attracted by the magnet*. It is well known, that the activity of a loadſtone or magnet reſides chiefly in two parts of it, which have been called its poles; and that thoſe are the beſt magnets or loadſtones in which this activity is leaſt diffuſed; and that a certain circumference of every loadſtone or magnet is wholly inactive. When a loadſtone or magnet of any ſhape is laid among iron filings, it collects them on two parts only of its ſurface, and between theſe there is a ſpace all round, to which no filings attach themſelves.

We preſume that the reader already explains this appearance to himſelf. Many things ſhew a contrariety of action of the two poles of a magnet. We have already obſerved, that the north pole of a ſtrong magnet will produce a ſtrong northern polarity in the remote end of a ſmall ſteel bar; and, if it be then applied near to that end in the oppoſite direction, it will deſtroy this polarity, and produce a ſouthern polarity. In whatever theſe actions may conſiſt, there is ſomething not only different but oppoſite. They do not blend their effects, as the yellow and blue making rays do in producing green. They oppoſe each other, like mechanical preſſures or impulſions. We have every mark of mechanical action; we have local motion, though unſeen, except in the gradual progreſſion of the magnetical faculties along the bar; but we have it diſtinctly in the ultimate effect, the approach or receſs of the magnets: and in theſe phenomena we ſee plainly, that the forces, in producing their effects, act in oppoſite directions. Whatever the internal inviſible motions may be, they are compoſed of motions whoſe equivalents are the ſame with the equivalents of the ultimate, external, ſenſible motions; therefore the internal motions are oppoſite and equal if the ſenſible motions are ſo, and converſely.

Adopting this principle, therefore, that the actions of the two poles are not only different but oppoſite, it follows, that if they are alſo equal and act ſimilarly, each muſt *prevent* the action of the other; and that there will be a mechanical equilibrium—it may even be called a magnetical equilibrium. Therefore if every part of a ſlender rod, or of a thin plate of iron, lie in the plane of the magnetic equator, the magnetic ſtate (in whatever it may conſiſt) cannot be produced in it. It will exhibit no magnetiſm; have no polar faculties; and we can ſee no reaſon why it ſhould be attracted by the magnet, or ſhould attract iron. We muſt not forget to obſerve in this place, that iron in a ſtate of incandeſcence acquires no magnetiſm by juxtapoſition. We have already remarked, that iron in this ſtate does not affect the magnet. If a bar of red hot iron be ſet near a mariner's needle, it does not affect it in the ſmalleſt degree till it almoſt ceaſes to appear red hot in day light, as has been obſerved by Dr Gilbert. All actions that we know are accompanied by equal and oppoſite re-actions; and we ſhould expect, what really happens in the preſent caſe, namely, that red hot iron ſhould not be rendered magnetical and attractable.

There is a very remarkable circumſtance which accompanies the whole of this communication of magnetiſm to a piece of iron. It does not impair the power of the magnet; but, on the contrary, improves it. This fact was obſerved, and particularly attended to, by Dr Gilbert. He remarks, that a magnet, in the hands of a judicious philoſopher, may be made to impart more magnetiſm than it poſſeſſes to each of ten thouſand bars of ſteel, and that it will be more vigorous than when the operations began. A magnet (ſays he) may be ſpoiled by injudicious treatment with other magnets, but never can touch a piece of common iron without being improved by it. He gives a more direct proof. Let a magnet carry as heavy a lump of iron as poſſible by its lower pole. Bring a great lump of iron cloſe to its upper pole, and it will now carry more. Let it be loaded with as much as it can carry while the lump of iron touches its upper pole. Remove this lump, and the load will inſtantly drop off. But the following experiment ſhews this truth in the moſt convincing manner:

Let NAS (fig. 11.) be a magnet, not very large, nor of extreme hardneſs. Let CD be a ſtrong iron wire, hanging perpendicularly from a hook by a ſhort thread or loop. The magnet, by its action on CD, renders D a north pole and C a ſouth pole, and the polarity of D's magnetiſm fits it for being attracted. Let it aſſume the poſition C *e*, and let this be very carefully marked. Now bring a great bar of iron *s* B near to the other end of the magnet. We ſhall inſtantly perceive the wire C *e* approach to the ſouth pole of the magnet, taking a poſition C *f*. Withdraw the bar of iron, and C *f* will fall back into the poſition C *e*. As we bring the iron bar gradually nearer to the magnet, the

the wire will deviate farther from the perpendicular, and when the bar B touches the magnet CD, will start a great way forward. It is also farther to be observed, that the larger the bar of iron is, the more will CD deviate from the perpendicular.

Now this must be ascribed to the action of the bar on the magnet. For if the magnet be removed, the bar alone will make no sensible change on the position of the wire. We know that the bar of iron becomes magnetical by the vicinity of the magnet. If we doubt this, we need only examine it by means of a piece of iron or a mariner's needle. This will shew us that *s* has become a south, and *n* a north pole. Here then are two magnets with their dissimilar poles fronting each other. In conformity with the whole train of magnetical phenomena, we must conclude that they attract each other, and must improve each other's magnetism.

This is a most important circumstance in the theory of magnetism. For it shews us, that, in rendering a piece of iron magnetic, there is no material communication. There is no indication of the transference of any substance residing in the magnet into the piece of iron; nor is there even any transference of a power or quality. Were this the case, or if the substance or quality which was in A be now transferred to B, it can no longer be in A; and therefore the pheonomena resulting from its presence and agency must be diminished. We must say that the magnet has excited powers inherent, but dormant, in the iron; or is, at least, the occasion of this excitement, by disturbing, in some adequate manner, the primitive condition of the iron. We must also say, that the competency of the magnet and of the iron to produce the phenomena, is owing to the same circumstances in both; because we see nothing in the phenomena which authorises us to make any distinction between them. Whatever therefore causes one magnet to attract another, is also the reason why a piece of iron in the neighbourhood of a magnet attracts another piece of iron; and we must say that the cause of polarity, or the origin of the directive power, is the same in both. Now we understand perfectly the directive power of a magnet, as exerted on another magnet. We see that it arises from a combination and mechanical composition of attractions and repulsions. It must be the same in this magnetism now inherent in the iron. The piece of iron directs a mariner's needle, as a magnet would direct it; therefore, as there is something in a piece of iron which *now* attracts something in another piece of iron, so there is something in the first which repels something in the last.

It may indeed be said that it is not a piece of iron, but a mariner's needle, or magnet, that is thus directed by our iron magnetised by vicinity to a magnet. This objection is completely removed by the most curious of all the facts which occur in this manner of producing magnetism. Take a piece of common iron, fashion it, and fit it up precisely like a mariner's needle, and carefully avoid every treatment that can make it magnetical. Set it on its pivot, and bring it near the north pole of a magnet, placing the end, made like the south pole of the needle, next to the north pole of the magnet. In short, place it by hand exactly as a real mariner's needle would arrange itself. It will retain that position. Now carry it round the magnet, along the circumference of a magnetic curve, or in any regular and continuous route. This piece of iron will, in every situation, assume the very same position or attitude which the real magnetical needle would assume if in the same place, and it will oscillate precisely in the same way.

Here then it is plain, that there is no distinction of power between the magnetism of the iron and of the real needle. To complete the proof: Instead of approaching the magnet with this iron needle, bring it into the vicinity of a piece of iron, which is itself magnetical only by vicinity to a magnet, it will arrange itself just as the real needle would do, with the sole difference, that it does not indicate the *kind* of polarity existing in the extremities of the iron, because either end of it will be attracted by them. And this circumstance leads us to the consideration of the only distinction between the magnetism of a loadstone or magnet and that of common iron.

41 Magnetism of iron is transitory and indifferent; but that of magnets is durable and determinate.

The magnetism of common iron is momentary, and therefore indifferent; whereas that of a magnet is permanent and determinate. When iron becomes magnetic in the way now mentioned, it remains so only while the magnet remains in its place; and when that is removed, the iron exhibits no signs of magnetism. Therefore when the north pole of a magnet has produced a south pole in the nearest end of an iron wire, and a north pole at the remote end, if we turn the magnet, and present its south pole, the nearest end of the wire instantly becomes a north pole, and the other a south pole; and this change may be made as often, and as rapidly, as we please. This is the reason which made us direct the experimenter on the iron needle to begin his operation by placing the end marked for a south pole next to the north pole of the magnet. It becomes a real south pole in situation, and acts as such during its peregrination round the magnet. But in any one of its situations, if we turn it half round with the finger, the end which formerly turned away from a pole of the magnet, will now turn as vigorously toward it. Therefore, in carrying the iron needle round the magnet, we directed the progress to be made in a continuous line, to avoid all chance of mistaking the polarities.

Magnetism of Induction.

For all the reasons now adduced, we think ourselves obliged to say, that the magnetism produced on common iron by mere juxtaposition to a magnet, is generated *without* any *communication* of substance or faculty. The power of producing magnetical phenomena is not *shared* between the magnet and the iron. We shall call it INDUCED MAGNETISM; MAGNETISM BY INDUCTION.

We have said that induced magnetism of common iron is quite momentary. This must be understood with careful limitations. It is strictly true only in the case of the finest and purest soft iron, free of all knots and hard veins, and therefore in its most metallic state. Iron is rarely found in a state so very pure and metallic; and even this iron will acquire permanent and determinate magnetism by induction, if it has been twisted or hammered violently, although not in the magnetic direction; also the changes produced (we imagine) on the purest iron by the action of the atmosphere make it susceptible of fixed magnetism. But the magnetism thus inducible on good iron is scarcely sensible, and of no duration, unless it has lain in the neighbourhood of a magnet for a very long while.

What has now been said of common iron, is also true of it when in the state of soft steel.

But

43 [T]empered [st]eel ac[q]uires du[ra]ble mag[ne]tism.

But any degree of temper that is given to steel makes a very important change in this respect. In the first place, it acquires magnetism more slowly by induction than an equal and similar piece of common iron, and finally acquires less. These differences are easily examined by the deviations which it causes in the mariner's needle from the magnetic meridian, and by its attraction.

When the inducing magnet is removed, some magnetism remains in the steel bar, which retains the polarity which it had in the neighbourhood of the magnet.

Steel tempered to the degree fit for watch springs acquires a strong magnetism, which it exhibits immediately on the removal of the magnet. But it dissipates very fast; and, in a very few minutes, it is reduced to less than one-half of its intensity while in contact with the magnet, and not two thirds of what it was immediately on removal from it. It continues to dissipate for some days, though the bar be kept with care; but the dissipation diminishes fast, and it retains at least one-third of its greatest power for any length of time, unless carelessly kept or injudiciously treated.

Steel tempered for strong cutting tools, such as chisels, punches, and drills for metal, acquires magnetism still more slowly by induction, and [illegible] less of it while in contact with the magnet [illegible] more firmly, and finally [illegible] of what it had acquired.

Steel made as hard as possible is much longer in acquiring all the magnetism which simple juxtaposition can give to it. It acquires less than the former; but it retains it with great firmness, and finally retains a much greater proportion.

Such ores of iron as are [illegible] of magnetism are nearly like hard steel in [illegible], that is in the time necessary for their [illegible], and in the durability of the acquired magnetism. They differ exceedingly [illegible] the degree of power which they can [illegible] by [illegible] juxtaposition, and the varieties seem to depend on [illegible]. We must observe, that [illegible] of magnetism in their natural state. The ordinary ores, consisting of the metal in the state of an oxyd, and combined with sulphur, are not magneticable while remaining in that state. Most ores require roasting, and a sort of cementation, in contact with inflammable substances. This matter is not well understood; but it would seem that complete metallization is far from being the most favourable condition, and that a certain degree of oxydation, and perhaps some other composition, yet unknown, make the best loadstones. But all this is extremely obscure. The late Dr Gowin Knight made a composition which acquired a very strong and permanent magnetism, but the secret died with him. Dr Gilbert speaks of similar compositions, in which ferrugineous clays were ingredients; but we know nothing of the state of the metal in them, nor their mode of acquiring magnetism.

44 [In]duction [of m]agne[tism] is gra[du]al and [pro]gressive.

It is of peculiar importance to remark that the acquisition of magnetism is gradual and progressive, and that the gradation is the more perceptible in proportion as the steel is of a harder temper. When a magnet is brought to one end of a bar of common iron, its remote extremity, unless exceedingly long, acquires its utmost magnetism immediately. But when the north pole of a magnet is applied to one end of a bar of hard steel, the part in contact immediately becomes a south pole, and the far end is not yet affected. We observe a north pole formed at some distance from the contact, and beyond this a faint south pole. These gradually advance along the bar. The remote extremity becomes first a faint south pole, and it is not till after a very long while (if ever) that it becomes a simple, vigorous, north pole. More frequently it remains a diffused and feeble north pole; nay, if the bar be very long, it often happens that we have a succession of north and south poles, which never make their way to the far end of the bar. This phenomenon was first observed (we think) by Dr Brook Taylor, who gives an account of his observations in the *Philosophical Transactions*, nº 344.

From the account we have given of these phenomena of induced magnetism, it appears that the temporary magnetism is always so disposed that the sum of the mutual attractions of the dissimilar poles exceeds the sum of the repulsions between the similar poles, and that therefore the two magnets tend to each other. This is evidently equivalent to saying, that a piece of unmagnetic iron is always attracted by a magnet. No exception has ever been observed to this fact; for Pliny's story of a Theamedes, or loadstone, which repels iron, is allowed by all to have been a fable. Iron is attracted only because it becomes magnetical.

We think ourselves authorised to say that this attraction of the loadstone for iron, or this tendency of iron to the loadstone, is a secondary phenomenon, and is the *consequence* of the proper disposition of the induced magnetism. The proofs already given of the compound nature of this phenomenon, namely, that it arises from the excess of two attractions above two repulsions, need (we imagine) no addition. But the following considerations place the matter beyond doubt:

1. The magnetism of the two poles is evidently of an opposite nature; the one repelling what the other attracts. If the one attracts iron, therefore, the other should repel it. But each pole, by inducing a magnetism opposite to its own, on the nearest end of the iron, and the same with its own on the remote end, and its action diminishing with an increase of distance, there must always be an excess of attraction, and the iron must be attracted.

2. Each of the magnets A and B, in either of the positions represented in fig. 12. would alone attract the piece of common iron C. But when placed together, the south pole of A tends to render the upper end of C a north pole; while the north pole of B tends to make it a south pole. If their actions be nearly equal, the weight of C cannot be supported by the magnetism induced by any difference of action that may remain. While C is hanging by B alone, let A be gradually brought near; it gradually destroys the action of the north pole of B, so that C gradually loses its magnetism and polarity, and its weight prevails.

3. In all those cases where the induction of magnetism is slow, the attraction is weak in proportion. This is particularly remarked by Dr Gilbert. If we take pieces of common iron, and of steel of different tempers, but all of the same size and form, we shall find that the iron is much more strongly attracted than any of the rest, and that the attraction for each of them is weaker in proportion as they are harder. This diversity is so accurately observed, that when the piece is thoroughly

susceptible of magnetism. we can tell, with considerable precision, what degree will be ultimately acquired, and how much will be finally retained. Also, the attraction of the magnet for any of those pieces of steel increases exactly in proportion as their acquired magnetism increases.

4. An ore of iron incapable of acquiring magnetism is not attracted by a magnet. But we know that, by cementation with charcoal dust, they may be rendered susceptible of magnetism. In this state they are attracted. It is an universal fact, that any substance that is attracted by a magnet may be rendered magnetical, and that none else can. We have already observed that red hot iron is not attracted; nor does it acquire any directive power while in that state. From all this we must conclude, that the previous induction of magnetism is the mean of the observed attraction of magnets for iron, and that this is not a primary fact in magnetism.

These observations also complete the proof that magnetic attraction and repulsion are equal at the same distance, and follow the same law. Dr Gilbert seems to think, that the repulsion is always weaker than the attraction; and this is almost the only mistake in conception into which that excellent philosopher has fallen. But it only requires a fair comparison of facts to convince a good logician, that since, *in every case*, and at every distance, either pole of a magnet attracts either end of a piece of common iron, it is impossible that one of these forces can exceed the other. It might be so, were it not that induced magnetism is durable in proper substances. And if we take magnets which have been made such by induction, and present them to each other with their similar poles fronting each other, they never fail to repel each other at considerable distances, and even at very small distances for a few moments; and this is the case whichever poles are next each other. This cannot be on any other supposition. Cases would occur of polarity without attraction, or of attraction without polarity. Such have never been seen, any more than the Theamedes, always repelling iron.

16 Some... of iron ...ls and ...s. Let a great number of small oblong pieces of iron be lying very near each other on the surface of quicksilver. Bring a strong magnet into the midst of them. It immediately renders them all magnetical by induction. The one nearest the north pole of the magnet immediately turns one end toward it, and the other end away from it. The same effect is produced on the one that is just beyond this nearest one. Thus the remote end of the first becomes a north pole, and the nearest end of the second becomes a south pole. These, being very near each other, must mutually attract. The same thing may be said of a third, a fourth; and so on. And thus it appears, that not only is magnetism induced on them all, but also, that the magnetism of each is so disposed, that both ends of it are in a state of attraction for the ends of some of its neighbours; and that they will therefore arrange themselves by coalescence in some particular manner. Should a parcel of them chance to be standing with their centres in a magnetic curve, with their heads and points turned in any ways whatever, the moment that the magnet is brought among them, and set in the axis of that magnetic curve, the whole pieces of this row will instantly turn towards each other, and their ends will adhere together, if they are near enough; otherwise they will only point toward each other, forming a set of tangents to the magnetic curve, reaching from one pole of the magnet to the other.

Or, suppose a vast number of small bits of iron, each shaped like a grain of barley, a little oblong. Let them be scattered over the surface of a table, so near each other as just to have room to turn round. Let a magnet be placed in the midst of them. They will all have magnetism induced on them in an instant; and such as are not already touching others, will turn round (because they rest on the table by one point only), and each will turn its ends to the ends of its neighbours; and thus they will arrange themselves in curves, which will not differ greatly from true magnetic curves (because each grain is very short), issuing from one pole of the magnet, and terminating in the other.

Does not this suggest to the reflecting reader an explanation of that curious arrangement of iron filings round a magnet, which has so long entertained and puzzled both the philosophers and the unlearned, and which has given rise to the Cartesian and other theories of magnetism? The particles of iron filings are little rags of soft iron torn off by the file, and generally a little oblong. These *must* have magnetism induced on them by a magnet; and, while falling through the air from the hand that strews them about the magnet, they are at perfect liberty to arrange themselves magnetically; and *must* therefore arrange themselves, forming on the table curves, which differ very little indeed from the true magnetic curves. Suppose them scattered about the table before the magnet is laid on it. If we pat the table a little, so as to throw it into tremors, this will allow the particles to dance, and turn round on their points of support, till they coalesce by their ends in the manner already described.

All this is the genuine and inevitable consequence of what Dr Gilbert has taught us of induced magnetism. It must be so; and cannot be otherwise. This curious arrangement of iron filings round a magnet is therefore not a primary fact, and a foundation for a theory, but the result of principles much more general.

Most of our readers know that this disposition of iron filings has given rise to the chief mechanical theories which have been proposed by ingenious men for the explanation of all the phenomena of magnetism. An invisible fluid has been supposed to circulate through the pores of a magnet, running along its axis, issuing from one pole, streaming round the magnet, and entering again by the other pole. This is thought to be indicated by those lines formed by the filings. The stream, running also through *them*, or around them, arranges them in the direction of its motion, just as we observe a stream of water arrange the flote grass and weeds. It would require a volume to detail the different manners in which those mechanicians attempt to account for the attraction, repulsion, and polarity of magnetic bodies, by the mechanical impulsion of this fluid. Let it suffice to say, that almost every step of their theories is in contradiction to the acknowledged laws of impulsion. Nay, the whole attempt is against the first rule of all philosophical discussion, never to admit for an explanation of phenomena the agency of any cause which we do not know to exist, and to operate in the very phenomenon. We know of no such fluid; and we can demonstrate, that the genuine effects of its impulsion would be totally unlike the phe-

47 Remarks on the theories by impulsion.

nomenon

nomena of magnetifm. But the proper refutation of thefe theories would fill volumes. Let it fuffice (and to every logician it will abundantly fuffice) to remark, that this phenomenon is but a fecondary fact, depending on, and refulting from, principles much more general, viz. the induction of magnetifm, and the attraction of diffimilar, and repulfion of fimilar, poles.

The above explanation of the curious difpofition of iron filings round a magnet, occurred to the writer of this article while ftudying natural philofophy, on feeing the Profeffor exhibit Mr Henfhaw's beautiful experiment in proof of terreftrial magnetifm *. He at that time imagined himfelf the author, and promifed himfelf fome credit for the thought. But having feen the *Phyfiologia Nova de Magnete* by Dr Gilbert, he found that it had not efcaped the notice of that fagacious philofopher; as will appear paft difpute from the following paffage, as well as fome others, lefs pointed, in that work: "Magnetica frufta (that is, fubftances fufceptible of magnetifm) bene et convenienter intra vires pofita, mutuo cohærent. Ferramenta, præfente magnete (etiamfi magnetem non attingant), concurrunt, folicité fe mutuo quærunt, et amplexantur, et, conjuncta, quafi ferruminantur. Scobs ferrea, vel in pulverem redacta, fiftulis impofita chartaceis—fupra lapidem meridionaliter locata, vel propius tantum [illegible] corpus; et fubito tam multæ partes [illegible] conjunguntur, ferrumque aliud affectat conjunctorum turma et attrahit, ac fi unum tantum et integrum effet ferri bacillum; dirigiturque fupra lapidem in feptentriones et meridiem. Sed cum longius a magnete removeantur (tanquam foluta rurfus) feparantur, et diffluunt fingula corpufcula." B. ii. c. 23.

See VARIATION Cycl. 621.

Mr Æpinus alfo had taken the fame view of the fubject *. It is alfo very clearly conceived and expreffed by the celebrated David Gregory, Savilian Profeffor of aftronomy in the Univerfity of Oxford, in a MS. volume of notes and commentaries, written by him in 1693, on Newton's *Principia*, and ufed by Newton in improving the fecond edition. The MS. is now in the library of the univerfity of Edinburgh. Gregory's words are as follow: "Mihi femper dubium vifum eft num magnetica virtus mechanicé, *i. e.* per impulfum, producatur. Mirum eft, effluvia, quæ ferrum agitare valent, bracteas aureas *interpofitas* ne vel minimum a loco movere. Lucretii et Cartefii theoriam, de fugato intermedio aëre, refutat experimentum infra aquam inftitutum. *Sulci in limatura ferri, magneti in plano cujufvis meridiani circumpofita, non fiunt ab effluviis fecundum ejus canales motis, fed ex inde, quod ipfa ramenta, magnetice excitata, fefe fecundum longitudinem et fecundum polos difponunt.* Ex altera vero parte exinde quod vis magnetica, interveniente flamma aut calore, interrumpatur, quod virga ferrea, vel diuturno fitu perpendiculari, vel in eo fitu frigefcendo, virtutem magneticam a tellure acquirat. ut nos docet perfpicaciffimus Gilbertus. Quod mallei fuper incudem ictu forti ad alterum extremum, virtutem acquirat magneticam; quod ictu forti vel faltem fortiori ad alterum extremum poli permutantur, ut qui prius feptemtriones refpiciebat nunc auftrum refpicit; quod ictu forti ad medium, virtutem illam prorfus amittat. Hæc inquam, et fimilia, mechanicam ejus qualitates ortum arguunt. Hugenius, præter gravitatem, etiam magneticam, et electricam virtutem, aliafque plures experimento novit vires naturales, ut mihi ipfi narravit hac eftate anni 1693. Qualis ut hæc forfitan quod cymba papyracea, prope labia vafis aquam, cui innatet, continentis, pofita, labrum viciniffimum continuo. et cum impetu petat (A)." *Nat. MS. in Prop.* 23. ii. *Prin.*

See § 306.

48 Filings are weakly attracted.

Not only the mere arrangement of the filings in curve lines follows of neceffity from the properties of induced magnetifm, but all the fubordinate circumftances of this phenomenon are included in the fame explanation. By continuing to tap the table, and throw it into tremors, the filings are obferved to approach gradually, but very flowly, to the poles of the magnet. Each particle is a very fmall temporary magnet. The attractive power of the great magnet, $\overline{m-p}-\overline{n-q}$, is therefore extremely fmall in proportion to its directive power, $\overline{m+p}-\overline{n+q}$. And we obferve that the accumulation of the filings round the poles of the magnet is fo much the flower as the filings are finer.

49 Curious fact.

If a paper be laid above the magnet, and the filings be fprinkled on it, we obferve them to conftipate along its edges, while none remain immediately above its fubftance; they are all beyond, or on the outfide of its outline, and they are obferved not to be lying flat on the paper, but to be ftanding obliquely on one point. They move off from the paper immediately above the magnet, becaufe they repel each other. They ftand obliquely from the edges, becaufe that is the direction of a magnetic meridian at its parting from the pole. If the magnet be at fome diftance below the paper, then tapping the paper will caufe the filings to move away from the magnet laterally. This fingular and unexpected appearance is owing to the combination of gravity with the magnetic action. A particle, fuch as *n s* (fig. . .), refts on the paper by the point *n*, which is a temporary north pole (S being fuppofed the fouth pole of the magnet). The particle takes a pofition *n s* nearer to the horizon than the pofition *n o*, which it would take if its centre of gravity *b* were fupported. The pofition is fuch, that its weight, acting vertically at *b*, is in equilibrio with the magnetic repulfion *s d*, exerted between S and *s*. When the paper is tapped, it is beaten down, or withdrawn from *n*, and the particle of iron is left for a moment in the air. It therefore turns quickly round *b*, in order to affume a pofition parallel to *n o*, and it meets the paper, as that rifes again after the ftroke, in a point farther removed from the magnet, and again defcends by its weight (turning round the newly fupported point *n*), till it again takes a pofition parallel to *n s*, but farther off, as reprefented by the dotted line. Thus it travels gradually outwards from the magnet, appearing to be repelled, although it is really attracted by it. If the magnet be held above the paper, at a little diftance, the filings, when we repeatedly pat the paper, gradually collect into a heap under it. This will appear very plainly to one who confiders the fituation of a particle in the manner now explained.

(A) Perhaps it may be proper to obferve, that Dr Gregory expreffes his differing in his opinion from Newton about magnetifm. Newton, in this propofition, thinks, that the law of magnetic action approaches to the inverfe triplicate ratio of the diftance. Dr Gregory invalidates the argument ufed by Newton.

The curve lines formed by very fine filings approach very nearly to the form of the primary curve which indicates the law of magnetic action in the way already explained. If the magnet be placed under water, and if filings be sprinkled copiously on the surface of it from a gauze searce, held at some distance above it, the resistance to their motion through the water gives them time to arrange themselves magnetically before they reach the bottom, and the lines become more accurate. But they were so much deranged by any method that we could take for removing the water, and measuring them, that we were disappointed in our expectations of obtaining a very near approximation to the law of action.

We took notice of some very singular phenomena of a compass needle in the neighbourhood of two magnets, and we observed that, in this case also, the needle was always a tangent to a curve of another kind, and which we called *secondary* and *compound magnetic curves*. These are produced in the same way, by strewing iron filings round the magnets. Many representations have been given of these curves by different authors, particularly by Muschenbroek, in his *Essais de Physique*; and by Fuss in the *Comment. Petropolit.* Great use has been made of these arrangements of filings by two magnets in the theories of magnetism proposed by those who insist on explaining all motion by impulse. When the dissimilar poles of two magnets A and B (fig. 14.) face each other, the curves formed by the filings considerably resemble those which surround a single magnet, and give the whole somewhat of the appearance of a magnet with very diffused poles. The arranging fluid, which streams from one pole of a magnet, is supposed to meet with no obstruction to its entry into the adjoining pole of the other magnet, but, on the contrary, to be impelled into it; and therefore (say the proposers) it circulates round both as one magnet, and by its vortex brings the magnets together; which phenomenon we call the attraction of the magnets. But when the similar poles front each other; for example, the poles from which the arranging fluid issues, then the two streams meet, obstruct each other, accumulate, and, by this accumulation, cause the magnets to recede from each other; which we call the repulsion of the magnets. This is the only explanation of this kind that can make any pretensions to probability, or indeed that can be conceived. For how the free circulation in the former case can bring the two magnets together, no person can form to himself any conception. We see nothing like this produced by any vortex that we are acquainted with. All such vortices cause bodies to separate. But even this explanation of magnetic repulsion is inadmissible. It will not apply to the repulsion of the receiving poles; and the phenomena of the filings are inconsistent with the notion of accumulation. The filings indeed accumulate, and they look not unlike two streams which oppose each other, and deflect to the sides (See fig. 15.): But, unfortunately, by tapping the paper gently, the filings do not move off from the magnets, but approach them much faster than in any other experiment. The phenomenon receives a complete and palpable explanation from the principles we have established. Both magnets concur in giving the same polarity to every particle of the filings. Thus, if the fronting poles are north poles, each particle has its nearest end made a vigorous south pole, and its remote end a north pole; and it is *therefore* strongly attracted towards both magnets while it is arranged in the tangent to the secondary curve of that class, which crosses the others nearly at right angles.

Since it is found, that the magnetism, even of natural loadstones and hard steel, and still more those of softer tempered steel, are continually tending to decay; and since we find that it may be induced by mere approach to a magnet; and since we know that magnets may oppose each other in producing it—it is reasonable to suppose, that when a piece of iron has acquired a slight, though permanent magnetism, by the vicinity of a magnet, a magnet applied in the opposite direction will destroy it, and afterwards produce the opposite magnetism. 52 Magnets must affect each other

Accordingly, we may change the poles of soft magnets at pleasure.

Farther; since we find that loadstones and hard tempered steel bars are distinguished from soft ones only by the *degree* of obstinacy with which they retain their present condition, we should also expect that hard magnets will even affect each other. It must therefore happen, that a powerful magnet applied to a weak one, so that their similar poles are in contact, shall weaken, destroy, and even change the magnetism of the weaker. Dr Knight's famous magazine of magnets enabled him to change the poles of the greatest and the strongest natural loadstone, or artificial magnet, that could be given him, in the space of one minute.

We now see clearly the reason why magnetic repulsion is weaker than attraction at the same distance. 53 Attraction must appear to exceed repulsion. When magnets are placed with their similar poles fronting each other, in order to make trials of their repulsion, they really do weaken each other, and are not in the same magnetical condition as before. For similar reasons, we see how experiments with magnets attracting each other rather improve them, and make their attractive powers appear greater than they are. All these effects must be most remarkable in soft magnets, especially when long.

We also see, that the observed law of attraction and repulsion between two magnets must be different from the real law of magnetic action. 54 The observed law differs from the true. For, in the experiments made on attraction at different distances, beginning with the greatest distance, the magnetism is continually increasing, and the attraction will appear to increase in a higher rate than the just one: the contrary may happen, if we begin with the smaller distances. The results of experiments on repulsion must be still more erroneous; because it is easier to diminish any accumulation which required an exertion to produce it, than to push it still farther.

We have now a complete explanation of the remarkable fact, that the induction of magnetism does not weaken the magnet employed; but, on the contrary, improves it. 55 Magnetism improves by inducing it on iron. The magnetism induced on the iron causes it to act on the magnet employed in the very same manner that a permanent magnet of the same shape, size, and strength, would do. Nay, it will have even a greater effect; for as it improves the magnet, its own induced magnetism will improve; and will therefore still farther improve the magnet.

Hence it is, that, in whatever manner a magnet touches a piece of iron, it improves by it. 56. It may be hurt by a magnet in an improper position; but it always puts common iron into a state which increases its own magnetism.

magnetism. This has been known as long as magnetism itself; and the ancients conceived the notion, that the magnet somehow fed upon the iron (B).

We think that these observations authorise us to say, that in reducing a loadstone into a convenient shape, as much as possible of the operation should be performed by grinding them with emery, in cavities made in large blocks of *hammered* iron. The magnetism induced on the iron must be favourable to the conservation of that in the loadstone; which, we are persuaded, is rapidly dissipated by the tremors into which this very elastic substance is thrown by the grinding with coarse powders in any mould but iron. We imagine, that the cutting off slices by the lapidaries wheel has the same bad effect.

Not only will a magnet lift a greater lump of iron by its north pole, when another lump is applied to its south pole, but it will lift a greater piece of iron from an anvil than from a wooden table; for the magnet induces the properly disposed polarity, not only in the iron which it lifts, but also in the anvil, or any piece of iron immediately beyond it. This is so disposed as to increase the magnetism of the piece of iron between them; and therefore to increase their attraction. The magnetism induced on the anvil is also in part, and perhaps chiefly, induced by the intervening iron. These experiments are extremely variable in their results.—Sometimes a small magnet will pull an iron wire from a large and strong one. Sometimes this will be done even by a piece of unmagnetic iron; and the results appear quite capricious. But they are accurately fixed, depending on the induced compound magnetism. Mr Æpinus has stated some of the more simple cases, in which we can tell which magnet shall prevail. But the unfolding even of these cases would take a great deal of room, and must be omitted here. Besides, we are too imperfectly acquainted with the degree of magnetism induced on the various parts of an iron rod, and the degree of magnetism inherent in the various parts of the magnets, to be able to say, with certainty, even in those simple cases, on which side the superiority of attraction will remain.

58 ting of icial nets.

We may now proceed to deduce from this theory (for so it may justly be called, since all is reduced to one fact) the process for communicating magnetism to bodies fitted for receiving and retaining it; that is, the method of making artificial magnets. We shall not employ much time on this, because the most approved methods have been delivered at length in the article MAGNETISM of the *Encyclopædia Britannica*; and therefore we shall just make such observations on them as serve to confirm, or to perfect them by the theory. We acknowledge, that we do not know the internal process by which magnetism is induced, nor even in what this magnetism consists. All that we know is, that the bringing the pole of a magnet near to any magnetisable matter, produces a magnetism of the kind opposite to that of the pole employed. We know that this is the case with both poles, and that it obtains at all the distances where magnetism is observed. We know that the action of one pole is contrary to that of the other; that is, it counteracts the other, prevents it from producing its effect, and destroys it when already produced: and we know, that the production of these effects resembles in its result the protrusion of something fluid through the pores of the body, constipating it in all remote parts; as if the virtue of a pole resided in this moveable matter. This is nearly all that we know of it; and by these facts and notions we must judge of the propriety and effect of all the processes for magnetising bodies.

The most simple method of magnetising a steel bar, is to apply the north pole of a magnet to that end which we wish to render a south pole. Attention to the effects of this application is very instructive. Have in readiness a very small compass needle, turning on its pivot. It should not exceed half an inch in length, and should be as hard tempered as possible, and strongly impregnated. Immediately after the application of the magnet, carry the needle along the side of the bar. If the bar be long, and very hard, we shall observe a south polarity at the place of contact; a north polarity at a small distance from it; beyond this a weak south polarity; then a weak and diffused north polarity, &c.; toward the remote end the polarity will be found very uncertain. The same thing may be discovered by laying a stiff paper on the bar, and sprinkling iron filings over it, and then gently tapping the paper, to make them arrange themselves in curve lines; which will point out the various poles, and shew whether they are diffused or constipated. It is very amusing and instructive to observe the progress of this impregnation. In a few minutes after the first application of the magnet, we shall perceive the state of magnetism very sensibly changed. The north pole will be farther from the magnet, and will be more distinct; the southern polarity will also be protruded, and may appear for a moment at the remote extremity. The change advances; but the progress is more slow, and at last is insensible. When the bar is not harder than the temper of a cutting tool, the process is soon over; and if the bar is but six or eight inches long, the remote end shews the north polarity in a very few minutes. When the bar is very hard, the progress of impregnation is greatly expedited by striking it so as to make it sound. If it be suspended by a string in a vertical position, and the magnet applied to its lower end, the striking it with a key will make it ring; and in this way make the progress of magnetization very quick: but it does not allow it to acquire all the magnetism that can be given it by a very strong magnet.

But this is a bad way of impregnation. It is seldom that uniform magnetism, with only two poles, and those

(B) So Claudian.——" Nam ferro nutrunt vitam, ferrique vigore
Vescitur, hoc dulces epulas, hoc pabula novit
Hinc proprias renovat vires, hinc fusa per artus
Aspera secretum servant alimenta vigorem
Hoc absente perit, tristi morientia torpent
Membra fame, venasque sitis consumit apertas."

Pliny says, " Sola hæc materia (ferrum) vires ab eo lapide, accipit retinetque longo tempore, aliud apprehendens ferrum, ut annulorum catena spectetur interdum, quod imperitum vulgus ferrum appellat vivum.

of equal ſtrength, can be given. Even when there are but two, the remote pole is generally diffuſed, and therefore feeble. It is much improved by employing two magnets, one at each end. And if the bar is not more than ſix or eight inches long, and good magnets are employed, the magnetiſm is abundantly regular. This, accordingly, is practiſed for the impregnation of dipping needles, which muſt not be touched, leſt we diſturb the centre of gravity of the needle. But in all caſes, this method is tedious, and does not give ſtrong magnetiſm.

The method which was uſually practiſed before we had obtained a pretty clear knowledge of magnetiſm, was to apply the pole of a magnet to one end of the bar, and paſs it along to the other end, preſſing moderately. This was repeated ſeveral times on both ſides of the bar, always beginning the ſtroke at the ſame end as at firſt, and, in bringing the magnet back to that end, keeping it at a diſtance from the bar. The effect of this operation was to leave the end at which we began the ſtroke poſſeſſed of the polarity of the pole employed.

A general notion of the proceſs may be given as follows, obſerving, however, that there occur very many great and capricious anomalies. When the north pole N (fig. 16.) of the magnet A is ſet on the end C of the bar CBD, a ſouth pole is produced at C, and a north pole at D, when the length of the bar is moderate. As the magnet advances ſlowly along the bar, the ſouthern polarity at C firſt increaſes, then diminiſhes, and vaniſhes entirely when N has arrived at a certain point *a*; after which, a northern polarity appears at C, and increaſes during the whole progreſs of the magnet. In the mean time, the northern polarity firſt produced at D increaſes till the magnet reaches a certain point *e*, then diminiſhes, vaniſhes when the magnet reaches a certain point *f*; after which, a ſouthern polarity appears at D, which increaſes till the magnet reaches D. Mr Brugmann, who firſt attended minutely to theſe particulars (for Gilbert ſpeaks of them pointedly), calls *a* and *f points of indifference*, and *e* the *culminating point* of the pole D, and *i* the culminating point of the pole C. Hardly can any general rule be given for the ſituation of theſe points, nor even for the order in which they ſtand; ſo great and capricious are the anomalies in an amazing ſeries of experiments narrated by Brugmann and by Van Swinden. Repeating the operation, and beginning at C, the northern polarity there is weakened (ſometimes deſtroyed), then reſtored, and continually increaſed during the reſt of the ſtroke. The ſouthern polarity at D is alſo firſt weakened, and ſometimes deſtroyed; then reſtored, and finally augmented. The points *i*, *a*, *e*, *f*, change their ſituations, and frequently their order.

Van Swinden has attempted to deduce ſome general laws from his immenſe liſt of experiments, avoiding every conſideration of a hypotheſis, or the leaſt conjecture by what means theſe faculties are excited. But though we have peruſed his inveſtigation with care and candor, we muſt acknowledge, that we have not derived any knowledge which can help us to predict the reſult of particular modes of treatment with any greater preciſion than is ſuggeſted by a ſort of common ſenſe, aided (or perhaps perverted) by a vague notion, that theſe energies reſide in ſomething, which avoids the pole of the ſame name, carrying along with it this diſtinctive energy or polarity. This conception tallies perfectly with theſe obſervations of Brugmann and Van Swinden; and admits of all the anomalies in the ſituation of Bergmann's indifferent and culminating points, if we only ſuppoſe that this motion is obſtructed by the particles of the body. We muſt leave this to the reflection of the reader, who will *gueſs* how, when the magnet is between C and *i*, this ſubſtance, avoiding the pole N of the magnet, eſcapes below it, and goes toward the farther end. As the magnet advances, it drives ſome of this back again, &c. &c. This is gratuitous; but it aids the fancy, which, without ſome conception of this kind, has no object of ſteady contemplation. We have no thought when we ſpeak of the generating at C, or *a*, or *e*, a faculty of ſome kind, by the exertion of the ſame faculty in N. The conception is too abſtracted, and much too complex. We muſt content ourſelves with knowing, that N produces a ſouth pole immediately under it, and a north pole everywhere elſe, or endeavours to do ſo. It is unneceſſary to inſiſt longer on this method: Common ſenſe ſhews it to be a very injudicious one.

This method was greatly improved by beginning the friction at the centre. Apply the north pole at the centre or middle of the bar, and draw it over the end intended for the ſouth pole. Having done this ſeveral times on one end on both ſides, turn the magnet, applying its ſouth pole to the middle of the bar, and drawing it ſeveral times over the end intended for the north pole.

It was ſtill more improved by employing two magnets at once, placed as in fig. 17. on the middle B of the bar, and drawing them away from each other, over the ends of it, as ſhewn by the directing darts, and repeating this operation. It is plain that, as far as we underſtand any thing of this matter, this proceſs muſt be much preferable to either of the former two. The magnets A and E certainly concur in producing a properly diſpoſed magnetiſm on all that lies between them; and therefore on the whole bar at the end of each ſtroke. The end C muſt become a north, and D a ſouth pole. Still, however, as the ſtroke goes on to the point of indifference, each magnet tends to weaken the polarity of the parts ſituated beyond it.

This method continued to be practiſed till about the year 1750. Mr Canton, availing himſelf of the experiments of Mr Mitchell of Cambridge, publiſhed his method by the DOUBLE TOUCH as it is called. See *Monthly Review* for 1785.

We need not repeat what has been detailed in the *Encyclopædia*, MAGNETISM, p. 440, &c., and ſhall only make ſome obſervations on the peculiar advantages of this proceſs, as preſcribed by Mitchell, Canton, and improved by Mr Antheaume, in his memoir *ſur les Aimans artificiels* 1766, which was crowned by the Academy of Sciences. (See alſo diſſertations on the ſubject by *Le Maire and Du Hamel*, 1745). 59 Method of double touch.

There is an evident propriety in the arrangement invented by Mr Mitchell, repreſented in fig. 18. The magnetiſm induced on the two pieces of ſoft iron AD and BC is an excellent method for *ſecuring* every acceſſion of magnetiſm to either of the bars. A good deal depends on the proper ſize and length of theſe pieces; and our ignorance of the interior proceſs obliges us to have recourſe to experiment alone for aſcertaining this. Whatever circumſtances induce the ſtrongeſt magnetiſm

on those pieces of iron, will cause them to produce the greatest effect on the steel bars; and this will be indicated by a greater attraction. Therefore that distance will be the best which enables two bars AB and DC to lift the greatest weight hung on the piece AD or BC. When we impregnated bars whose breadth was about one tenth of their length, and their thickness about one-half of their breadth, we found, that if AD was about one fourth, or nearly one third, of AB, they carried more than if it was either much longer or much shorter. Mr Antheaume's addition of the two great bars of iron E and F makes a sensible improvement of the *beginning* of the impregnation, when very weak magnets are employed; but did not seem to us to be of any farther service on the table. This is agreeable to any theory which can be established by what we have said hitherto.

The method of employing the magnets A and E (fig. 19.), prescribed by Mitchell and Canton, is extremely judicious. The meeting of the dissimilar poles at top increases the magnetism of each. The two dissimilar poles F and G, certainly tend to give a regular and proper magnetism to the part FG of the bar which lies between them; and this is the case on whatever part of the bar they are placed. But each pole tends to destroy the present magnetism of what lies between it and the pole of the bar on that side. But when they tend to produce the desired magnetism on what lies between them with the sum of their forces, while each tends to destroy the magnetism of the part without it by the *difference* only of their forces. Therefore, on the whole, as they are moved to and fro along the bar, and the foremost one even made to pass over the end of it a little way, they always add to the magnetism already acquired. This consideration seems to enjoin setting F and G extremely near each other; for this seems to increase the sum, and to diminish the difference of their action. But it may be a question, Whether we gain more by strongly magnetising a very small part during the very short while that the magnets pass over it, or by acting on more of the bar at once, and continuing a weaker action for a longer while on this larger portion. Mr Æpinus adds another consideration depending on his notion of the internal process; but we defer this to another opportunity. The safest direction seems to be, to place them at the distance which enables them to lift the greatest weight. They are then undoubtedly acting with the greatest effect.

Mr Antheaume directs to place the touching magnets as in fig. 20. for a reason to be mentioned afterwards. Mr Æpinus also recommends it for reasons founded on his own hypothesis. We must say, that, in our trials, we have found this method very sensibly superior, especially in the latter parts of the operation, when the resistance to farther impregnation becomes nearly a balance for the accumulating power of the magnets; and we consider this as no inconsiderable argument for the justice of Mr Æpinus's hypothesis.

The great advantage of this method is the regularity of the magnetism which it produces. We never find more than two poles; and when the bars are hard, and of uniform texture, the polarity is very little diffused, and seemingly confined to a very small space at the very extremities of the bar. This is indeed a prodigious advantage in point of strength. It is no less so in order to fit the magnets for experiments on the law of magnetic action; for the latitude which the diffused condition of the poles gives in the selection of the points from which the distances are to be computed, has hitherto hindered us from pronouncing on the law of magnetic action with the precision of which we think it fully susceptible. This method also is the only one by which we have been able to impregnate two bars joined end to end, considering them as one bar. We have sometimes (though very rarely) succeeded in this; so that when filings were strewed over them, the appearance could not be distinguished from a single bar.—*N. B.* Yet even in this case, in one experiment with two bars of six inches long, treated as one, when it could not be distinguished, either by the appearance of the filings, or by going round it very near with a compass needle, a very small compass needle discovered a neutral point, and a reversion of polarity similar to fig. 14. at F, shewing that it was really acting as two bars. Perhaps it must always be so; and this question is of considerable importance in the establishment of any theory of the internal process.

It deserves remark, that, in order to succeed in this attempt, a very considerable pressure is necessary. We were obliged to clean the ends of the bars very carefully, and to force the frame of bars and soft pieces of iron strongly together by wedges, in the manner of a form of types. We thought that wetting the ends of the bars with pure water aided the experiment; and we are *very certain* that oil not only greatly obstructed it, but even sensibly impeded the common process. We had put a single drop of oil on a pair of bars which we were touching in the common Cantonian method, that the magnets might be more easily drawn along them; but we were surprised at finding that we could not give a strong impregnation. The oil undoubtedly prevents the close contact. We found the finest gold leaf produce the same effect in a great degree; as also talc, of which a square inch weighed $\frac{1}{13}$th of a grain. We do not infer any thing like obstruction to the passage of something material, but rather ascribe it to mere distance; although we are of opinion, that in the impregnation of two contiguous bars, so that the magnetism (whatever it is) is disposed *precisely* as in one bar, there *is* a material transference. But we shall speak of this in its due place.

It is not unworthy of remark, that we found bars to acquire more powerful magnetism when pretty well polished than when rough. But we also found, that bars considerably rough acquired the first degrees of it much more expeditiously than those which are smooth; although we never could bring them to that high degree of magnetism that the same bars acquired after they had been polished. We think it probable, that the tremors, occasioned by the rough and harsh surfaces of the hard steel, are the causes of this phenomenon.

Some more observations on this method of the double touch will be made afterwards, when we consider the hypothesis of Mr Æpinus: and we conclude the present subject, by attempting to explain some puzzling appearances which frequently occur in making artificial magnets.

A bar touched by a very strong magnet has been said by Muschenbroek to be impaired by going over it with a weaker magnet. If it had been made as strong

Difficulties explained.

as possible, the weaker magnet, when passed over it in the way practised by Muschenbrock, must *first* destroy part of this magnetism; and having done so, it is unable to raise it anew to the same degree of vigour.

Yet (says Muschenbrock with surprise) a large bar of common iron has greatly improved the magnet. A very large piece of iron *must* do this (especially if shaped like a horseshoe, and applied with both heels), if the bar be not already at its maximum.

It was thought wonderful, that, in the method of double touch, not only was the magnetism of the magnets employed not impaired, but, beginning with two magnets, whose power is almost insensible, and repeating the operations in the precise manner described by Mitchell or Canton, not only the bars intended to be made magnetical, but also the magnets employed, may be brought to their highest possible state of magnetism. This is in evident conformity to the general facts of induced magnetism, and affords the strongest proof that nothing is communicated in this operation, but that powers residing in the bars are excited, or brought into action. The manipulation merely *gives occasion* to this action, as a spark of fire kindles a city.

There still remain some circumstances of this method, as practised by Savery, Canton, and Antheaume, which are extremely curious and important.

Mr Savery had observed a small bit of steel acquire very sensible magnetism by lying long in contact with the lower end of a great window bar. Telling this to a friend, he was, for the first time, informed, that this had been long observed, and that Dr Gilbert had made some curious inferences from it. Mr Savery wanted some magnets, and was at a distance from town. Reflecting, like a philosopher, on what he had heard, and observed, he saw here a source of magnetism which he could increase, in the manner commonly practised in making magnets. He placed the bar AB (fig. 21.) to be magnetised between two great bars of common iron C and D, placing all the three in the magnetical direction. He took another bar EF, and put two little pieces of iron, like the armour of a loadstone, on its ends; and with those ends he rubbed the bar AB, rubbing the upper half of it with the end F, and the lower with the end E. The result of this was a very brisk magnetism in a few minutes, which, by various well devised alternations, he brought to its highest degree. His numerous experiments published in the Philosophical Transactions in 1746, contain much curious information, highly deserving the attention of the philosophers. Mr Canton, proceeding on the same principle, that bars of iron, which have been long in a vertical position, acquire an efficient magnetism, begins his operations by placing his steel bar on the head of a kitchen poker, and rubs it with the lower end of a pair of kitchen tongs. Mr Antheaume adheres more strictly to the inferences from the principle of terrestrial magnetism, and repeats precisely the previous disposition of things practised by Mr Savery, placing his little steel bar AB (fig. 22.) between two great bars C and D of common iron, and arranging the whole in the magnetic direction. Then, proceeding most judiciously on the same principle, he greatly improves the process, by employing two bars EF and GH for the touch, holding them about an inch apart, inclined about 15° to the bar AB. It is plain, that the lower end of each of these five bars is a north pole, and the upper end a south pole. Therefore the poles F and G concur in giving the proper magnetism to the portion FG of the steel bar which is between them; and by rubbing it with these poles up and down, overpassing each extremity about half an inch, he must soon give to the bar AB a regular magnetism; weak, perhaps, but to be afterwards increased in the Cantonian method, on a horizontal table. In this manner did Mr Antheaume make magnets of very great strength in 1766. See his *Dissertation* already quoted.

These observations naturally bring us to the PHYSIOLOGIA NOVA DE MAGNETE ET CORPORIBUS MAGNETICIS of Dr Gilbert; a discovery which the sagacious Kepler classes among the greatest in the annals of science. 62 Gilbert terrestl magnet

It could not be that a phenomenon so general, and so interesting and important as the natural polarity of magnetic bodies, would be long known without exciting curiosity about its cause. Accordingly the philosophers of the 16th century speculated much about it, and entertained a variety of opinion, if that can be called an opinion which can hardly be said to express a thought. We have in *Marsigli Ficino* a short notice of many of these opinions. Some maintained that the needle was directed by a certain point in the heavens, as if that were saying more than that it always pointed one way. Others, with more appearance of reasoning, ascribed the direction to vast magnetic rocks. But all this was without giving themselves the trouble of trying to ascertain what situation of such rocks would produce the direction that is observed. Fracastori was, if we mistake not, the first who thought this trouble at all necessary; and he observes very sensibly, that if those rocks are supposed to be in any place yet visited by navigators, and if they act as loadstones do (a circumstance which he says must be admitted, if we attempt to explain), the direction of the needle will be very different from what we know it to be. He therefore places them in the inaccessible polar regions, but not in the very pole. Norman, the discoverer of the dip of the mariner's needle, or of the true magnetic direction, was naturally led by his discovery to conceive the directing cause as placed in the earth; because the north point of the needle, in every part of Europe, points very far below the horizon. But although he calls the treatise in which he announces his discovery the *New Attractive*, he does not express himself as supposing the needle to be attracted by any point within the earth, but only that it is always directed to that point.

It is to Dr Gilbert of Colchester that we owe the opinion now universally admitted, that magnetic polarity is a part of the constitution of this globe. Norman had, not long before, discovered, that if a steel needle be very exactly balanced on a horizontal axis, like the beam of a common balance, so that it would retain any position given it, and if it be then touched with a magnet, and placed on its axis in the magnetic meridian, it is no longer in equilibrio, but (at London) the north point of it will dip 72 or 73 degrees below the horizon. He did not, however, publish his discovery till he had obtained information how it stood in other parts of the world. The differences in the variation in different places naturally suggested the necessity of this to him. Being a maker of mariners compasses,

passes, and teacher of navigation in London, he had the fairest opportunities that could be desired, by furnishing dipping needles to such of the navigators, his scholars, as he knew most able to give him good information. And the accounts which he received made his discovery, when announced to the world, a very complete thing; for the commanders of ships engaged in long voyages, and particularly to China, informed him that, in the vicinity of the equator, his dipping needles remained parallel to the horizon, but that in coming toward the north pole, the north end of the needle was depressed, and that the south end dipped in like manner at the Cape of Good Hope, and in the Indian Ocean; that the needle gradually approached the horizontal position as the ship approached the equator, but that in coming to the north of it at Batavia, the north point again dipped, and at Canton was several degrees below the horizon.

On these authorities, Norman boldly said that, in the equatoreal regions, the needle was horizontal, and that either end dipped regularly as it approached either pole; and that in the poles of the earth, the needle was perpendicular to the horizon. He therefore announced this as a discovery, not only singularly curious, but also of immense importance; for by means of a dipping needle the latitude of a ship at sea may be found without seeing the sun or stars.

Dr Gilbert, comparing this position of the compass needle with the positions which he had observed small needles assume in his numerous experiments in relation to a magnet, as we have described at great length, was naturally led to the notion of the earth's being a great loadstone, or as containing one, and that this arranged the dipping, or, in general, the mariner's needle in the same manner as he observed a great magnet arrange a small needle poised on its pivot. He therefore composed his *Physiologia Nova de Magnete, et de Tellure magno Magnete*; in which he notices so many points of resemblance to the directive power of a magnet, that the point seems no longer to admit of any doubt. Dr Gilbert's theory may be thus expressed:

All the phenomena of natural magnetism are analogous to what we should observe, if the earth were a great magnet, having its poles near the poles of the earth's equator, the north pole not far from Baffin's Bay, and the south pole nearly in the opposite part of the globe. A dipping needle, under the influence of this great magnet, must arrange itself in a plane which passes through the poles of the magnet, the position of which plane is indicated (at least nearly) by the ordinary compass needle; and it will be inclined to the horizon so much the more as we recede from the equator of the great magnet.

This opinion of Dr Gilbert was not less ingenious than important; and if firmly established, it furnishes a complete theory of all the phenomena of magnetism. But observations were neither sufficiently numerous in the time of Dr Gilbert, nor sufficiently accurate, to enable that great genius to assign the position of this great magnet, nor the laws of its action. The theory was chiefly founded on the phenomena of the dipping needle; phenomena which might have been unknown for ages, had the first notice of them fallen into any other hands than Norman's. They are not, like those of variation, which might be made by any sailor. They require for their exhibition a dipping needle, and the attention to circumstances which can occur only to a mathematician. A dipping needle is to this day, notwithstanding all our improvements in the arts, one of the most delicate and difficult tasks that an instrument maker can take in hand, and a good one cannot be had for less than twenty guineas. We are confident that such as even Norman could make were far inferior to what are now made, and quite unfit for use at sea while the ship is under sail, although they may be tolerably exact for an observation of the dip in any port; and we presume that it was such observations only that Norman confided in. Our readers will readily conceive the difficulty of poising a needle with such a perfect coincidence of its centre of gravity and axis of motion, and perfect roundness of this axis, that it shall remain in any position that is given it. Add to this, that a grain of dust, invisible to the nicest eye, getting under one side of this axis, may be sufficient for making it assume another position. It must also be a difficult matter to preserve this delicate thing, so as that no change can happen to it. Besides, all this must be performed on a piece of tempered steel which we are certain has no magnetism. Where can this be got, or what can insure us against magnetism? Nor is there less difficulty in making the observations without great risk of error. If the needle, moveable only in a vertical plane, be not set in the plane of a magnetic meridian, it will always dip too much. At London, where the magnetic direction is inclined 73° to the horizon, if it be in a plane 20° from the magnetic meridian, it will stand almost perpendicular; for it is easy to see, by the mechanical resolution of forces, that it will take the position which brings it nearest to the true magnetic direction. This, we think, is confirmed by several of Norman's and other old observations of dip. They are much greater than they have been since found in the same places.

Mr Daniel Bernoulli has given a very ingenious principle, by which we can make a dipping needle which will give a very accurate observation on shore; and being so easily executed, it deserves to be generally known. Let a dipping needle be made in the best manner that can be done by a workman of the place, and balanced with some care before impregnation, so that we may be certain that when touched it will take nearly the true dip. Touch it, and observe the dip. Destroy its magnetism, and then alter its balance in such a manner that, without any magnetism, it will arrange itself in the inclination of the observed dip. Now touch it again, giving it the same poles as before. It is plain that it will now approach exceedingly near indeed to the true dip, because its want of *perfect* equilibrium deranged it but a few degrees from the proper direction. If this second observation of the dip should differ several degrees from the first, by the inaccurate first formation of the needle, it will be proper to repeat the operation. Very rarely indeed will the third observation of the dip vary from the truth half a degree. Daniel Bernoulli's dipping needle.

Mr Bernoulli makes this simple contrivance answer the purpose of an universal instrument in the following ingenious manner. A very light brass graduated circle EFG (fig. 23.) is fixed to one side of the needle, concentric with its axis, and the whole is balanced as nicely as possible before impregnation. A very light index

CD is then fitted on the axis, ſo as to turn rather ſtiffly on it. This will deſtroy the equilibrium of the needle. If the needle has been made with perfect accuracy, and perfectly balanced, the addition of this index would cauſe it always to ſettle with the index perpendicular to the horizon, whatever degree of the circle it may chance to point at. But as this is ſcarcely to be expected, ſet the index at various degrees of the circle, and note what inclination the unmagnetic needle takes for each place of the index, and record them all in a table. Suppoſe, for example, that when the index is at 50, the needle inclines 46° from the horizon. If in any place we obſerve that the needle (rendered magnetic by lying between two ſtrong magnets), having the index at 50, inclines 46°, we may be certain that this is the dip at that place; for the needle is not deranged by the magnetiſm from the poſition which gravity alone would give it. As we generally know ſomething of the dip that is to be expected in any place, we muſt ſet the index accordingly. If the needle does not ſhew the expected dip, alter the poſition of the index, and again obſerve the dip. See whether this ſecond poſition of the index and this dip form a pair which is in the table. If they do, we have got the true dip. If not, we muſt try another poſition of the index. Noticing whether the agreement of this laſt pair be greater or leſs than that of the former pair, we learn whether to change the poſition of the index in the ſame direction as before, or in the oppoſite. The writer of this article has a dipping needle of this kind, made by a perſon totally unacquainted with the making of philoſophical inſtruments. It has been uſed at Leith, at Cronſtadt in Ruſſia, at Scarborough, and at New York, and the dip indicated by it did not in any ſingle trial differ 1½ degrees from other trials, or from the dip obſerved by the fineſt inſtruments. He tried it himſelf in Leith Roads, in a rough ſea; and does not think it inferior, either in certainty or diſpatch, to a needle of the moſt elaborate conſtruction. It is worthy of its moſt ingenious author, and of the public notice, becauſe it can be made for a moderate expence, and therefore may be the means of multiplying the obſervations of the dip, which are of immenſe conſequence in the theory of magnetiſm, and for giving us an accurate knowledge of the magnetical conſtitution of this globe.

Opinion reſpecting the great magnet contained in this globe.

This knowledge is ſtill very imperfect, owing to the want of a very numerous collection of obſervations of the dip. They are of more importance than thoſe of the horizontal deviations from the meridian. All that we can ſay is, that the earth acts on the mariner's needle as a great loadſtone would do. But we do not think that the appearances reſemble the effects of what we would call a good loadſtone, having the regular magnetiſm of two vigorous poles. The dips of the needle in various parts of the earth ſeem to be ſuch as would reſult from the action of an extremely irregular loadſtone, having its poles exceedingly diffuſed. The increaſe of the dip, as we recede from thoſe places where the needle is horizontal, is too rapid to agree with the ſuppoſition of two poles of conſtipated magnetiſm, whether we ſuppoſe the magnetic action in the inverſe ſimple or duplicate ratio of the diſtances, unleſs the great terreſtrial magnet be of much ſmaller dimenſions than what ſome other appearances oblige us to ſuppoſe. If there be four poles, as Dr Halley imagined, it will be next to impoſſible to aſcertain the poſitions of the dipping needle. It will be a tangent to one of the ſecondary magnetic curves, and theſe will be of a species. We cannot but conſider the diſcovery of the magnetic conſtitution of this globe as a point of very great importance, both to the philoſopher and to ſociety. We have conſidered it with ſome care; but hitherto we have not been able to form a ſyſtematic view of the appearances which gives us any ſatiſfaction. The well informed reader is ſenſible, that the attempt by means of the horizontal or variation needle is extremely tedious in its application, and is very unlikely to ſucceed; at the ſame time it muſt be well underſtood. The two diſſertations by Euler, in the 13th and 22d volumes of the Memoirs of the Royal Academy at Berlin, are moſt excellent performances, and give a true notion of the difficulty of the ſubject. Yet, even in theſe, a circumſtance is overlooked, which, for any thing we know to the contrary, may have a very great effect. If the magnetic axis be far removed from the axis of revolution, as far, for example, as Mr Churchman places it, the magnetic meridians will be (generally) much inclined to the horizon; and we ſhall err very far, if we ſuppoſe (as in Euler's calculus) that the dipping needle will arrange itſelf in the vertical plane, paſſing through the direction of the horizontal or variation needle; or if we imagine that the poles of the great magnet are in that plane. We even preſume to think that Mr Euler's aſſumption of the place of his fictitious poles (namely, where the needle is vertical), in order to obtain a manageable calculus, is erroneous. The introduction of this circumſtance of inclination of the magnetic meridians to the horizon, complicates the calculation to ſuch a degree as to make it almoſt unmanageable, except in ſome ſelected ſituations. Fortunately, they are important ones for aſcertaining the places of the poles. But the inveſtigation by the poſitions of the dipping needle is incomparably more ſimple, and more likely to give us a knowledge of a multiplicity of poles. The conſideration of the magnetic curves (in the ſenſe uſed in the preſent article), teaches us that we are not to imagine the poles immediately under thoſe parts of the ſurface where the needle ſtands perpendicular to the horizon, nor the magnetic equator to be in thoſe places where the needle is horizontal; a notion commonly and plauſibly entertained. Unfortunately our moſt numerous obſervations of the dip are not in places where they are the moſt inſtructive. A ſeries ſhould be obtained, extending from New Zealand northward, acroſs the Pacific Ocean to Cape Fairweather on the weſt coaſt of North America, and continued through that part of the continent. Another ſeries ſhould extend from the Cape of Good Hope, up along the weſt coaſt of Africa to the tropic of Capricorn; from thence acroſs the interior of Africa (where it would be of great importance to mark the place of its horizontality) through Sicily, Italy, Dalmatia, the eaſt of Germany, the Gulph of Bothnia, Lapland, and the weſt point of Greenland. This would be nearly a plane paſſing through the probable ſituations of the poles. Another ſeries ſhould be made at right angles to this, forming a ſmall circle, croſſing the other near Cape Fairweather. This would paſs near Japan, through Borneo, and the weſt end of New Holland; alſo near Mexico, and a few degrees weſt of Eaſter Iſland. In this place, and at Borneo, the

See VARIATION, Encycl.

the inclination of the magnetic plane to the horizon would be conſiderable, but we cannot find this out. It may, however, be diſcovered in other points of this circle, where the dip is conſiderable. We have not room in this ſhort account to illuſtrate the advantages derived from theſe ſeries; but the reflecting reader will be very ſenſible of them, if he only ſuppoſes the great magnet to be accompanied by its magnetic curves, to which the needle is always a tangent. He will then ſee that the firſt ſeries from New Zealand to Cape Fairweather, and the ſecond from Cape Fairweather round the other ſide of the globe, being in one plane, and at very different diſtances from the magnetic axis, muſt contain very inſtructive poſitions of the needle. But we ſtill confeſs, that when we compare the dips already known with the variations, they appear ſo irreconcileable with the reſults of an uniform regular magnetiſm, that we deſpair of ſucceſs. Every thing ſeems to indicate a multiplicity of poles, or, what is ſtill more adverſe to all calculation, an irregular magnetiſm with very diffuſed polarity.

Much inſtruction may ſurely be expected from the obſervations of the Ruſſian academicians and their eleves, who are employed in ſurveying that vaſt empire; yet we do not meet with a ſingle obſervation of the dip of the needle in all the bygone publications of that academy, nor indeed are there many of the variation.

65 ...d concerning the ...ation of poles. For want of ſuch information, philoſophers are extremely divided in their opinions of the ſituation of the magnetic poles of this globe. Profeſſor Krafft, in the 17th volume of the Peterſburgh Commentaries, places the north pole in lat. 79° N. and long. 23° W. from London; and the ſouth pole in lat. 50° S. and long. 92° E.

Wilcke of Stockholm, in his indication chart (*Swed. Mem.* tom. xxx. p. 218.), places the north pole in N. Lat. 75°, near Baffin's Bay, in the longitude of California. The ſouth pole is in the Pacific Ocean, in lat. 70° S.

Churchman places the north pole in lat. 59° N. and long. 135° W. a little way inland from Cape Fairweather; and the ſouth pole in lat. 59° S. Long. 165° E. due ſouth from New Zealand.

A planiſphere by the Academy of Sciences at Paris for 1786, places the magnetic equator ſo as to interſect the earth's equator in long. 75°, and 155° from Ferro Canary Iſland, with an inclination of 12 degrees nearly, making it a great circle very nearly. But we are not informed on what authority this is done; and it does not accord with many obſervations of the dip which we have collected from the voyages of ſeveral Britiſh navigators, and from ſome voyages between Stockholm and Canton. Mr Churchman has given a ſketch of a planiſphere with lines, which may be called parallels of the dip. Thoſe parts of each parallel that have been aſcertained by obſervation are marked by dots, ſo that we can judge of his authority for the whole conſtruction. It is but a ſketch, but gives more ſynoptical information than any thing yet publiſhed. The magnetic equator cuts the earth's equator in long. 15°, and 195° E. from Greenwich, in an angle of nearly 17 degrees. The circles of magnetic inclination are not parallel, being conſiderably nearer to each other on the ſhort meridian than on its oppoſite. This circumſtance, being founded on obſervation, is one of the ſtrongeſt arguments for the exiſtence of a magnet of tolerable regularity, as the cauſe of all the poſition of the compaſs needle; for ſuch *muſt* be the poſitions of the circles of equal dip, if the axis of this magnet is far removed from the axis of rotation, and does not interſect it.

Now, if the ſituation of the poles be any thing near the average or medium of theſe determinations, and if we form all our notions by analogy, comparing the poſitions of the compaſs needle in relation to the great terreſtrial magnet, with the poſitions aſſumed by a ſmall needle in the neighbourhood of a magnet, we muſt conclude, that the magnetical conſtitution of this globe has little or no reference to its regular external form. The axis of the magnet is very far removed from that of the globe (at leaſt 1500 miles), and is not nearly parallel to it, nor in the ſame plane. It required the ſagacity and the ſkill of a Euler to ſubject ſuch anomalous magnetiſm to any rules of computation; and every perſon qualified to judge of the ſubject muſt allow his diſſertation in the 13th volume of the Berlin Memoirs to be a work of wonderful reſearch. It is a very agreeable thing to ſee ſuch a conformity between the lines which expreſs the regular magnetiſm of Euler's diſſertation, and the lines drawn by Dr Halley from obſervation, and which appeared to himſelf ſo capricious, that he deſpaired (notwithſtanding his conſummate ſkill in geometry) of their ever being reduced to a mathematical and preciſe ſyſtem. 66.

Without detracting from the merit of Dr Gilbert, we may preſume to ſay that his notion of the earth's being a great magnet was not, in his mind, more than a ſagacious conjecture, formed from a very general and even vague compariſon. Yet the compariſon was ſufficiently good to give him great confidence in his opinion that the action of this great magnet, in perfect conformity to what we obſerve in our experiments with magnets, is the ſource of all the magnetiſm that we obſerve. If there was nothing elſe in proof of the juſtneſs of his theory, it is abundantly proved by the beautiful experiment of Mr Henſhaw, mentioned in the article VARIATION, *Encycl.* p. 621. col. 2. An iron bar held nearly upright, attracts the ſouth end of a compaſs needle with its lower end; and if that end of the bar be kept in its place, and the bar turned round till it becomes the upper end, the ſouth point of the needle immediately turns away from it, and the north end is now attracted. This experiment may be perfectly imitated with artificial magnetiſm. 67 Confirmations of Dr Gilbert's phyſiology.

Having ſupported a large magnet SAN (fig. 24.), ſo that its ends are detached from ſurrounding bodies, place a ſmall needle B (poiſed on its pivot) about three inches below the north pole N of the magnet, and in ſuch a ſituation that its polarity to the magnet may be very weak. Take now a ſmall piece of common iron, and hold it in the poſition repreſented at C. Its lower end becomes a north pole, attracting the ſouth pole of the needle. Keeping this in its place, turn round the piece of iron into the poſition D; the ſouth pole of B will now avoid it, and the north pole will be attracted. We directed the needle to be ſo placed, that its polarity, in relation to the magnet, may be weak. If it be ſtrong, it may act on the end of C or D like a magnet, and counteract the magnetiſm induced on C or D by vicinity to A.

An anonymous writer in the Philosophical Transactions, No 177. Vol. XV. relates several observations made during a voyage to the East Indies, which are quite conformable to this. A few leagues northwest from the island Ascension, the south point of the compass needle hardly shewed any tendency to or from the lower end of an iron bar. It seemed rather to avoid the upper end; it was not in the least affected by the middle of the bar; but when the bar was laid horizontal, in the magnetic direction, its two ends affected the dissimilar ends of the compass needle very strongly; but when horizontal, and lying at right angles to the magnetic direction, its polarity was altogether indifferent.

As the other phenomena of induced artificial magnetism have the same resemblance to the phenomena of natural magnetism, a bar which has remained long in the vicinity of a magnet acquires magnetism (permanent) in the same way, and modified by the same circumstances, as in natural magnetism. Hammering a bit of common iron in the immediate vicinity of a magnet, gives it very good magnetism. Exposing a red hot bar to cool in the neighbourhood of a magnet has the same effect. Also quenching it suddenly has the same effect. Quenching a small red hot steel bar between two magnets, was found by us to communicate a much stronger magnetism than we could give it by any other method. Its form indeed was very unfavourable for the ordinary method of touching; for it consisted of two little spheres connected by a slender rod, and could scarcely be impregnated in any other way than by placing it for a very long while between magnets. In all these experiments, the polarity acquired is precisely similar to that acquired by the same treatment in relation to this supposed great terrestrial magnet. In short, in whatever manner we pursue this analogy in our experiments, we find the resemblance most perfect in the phenomena.

We cannot but think, therefore, that this new physiology of the magnet by Dr Gilbert is well established; and we think ourselves authorised to assume it as a proposition fully demonstrated, that the earth is a great magnet, or contains a great magnet, the agency of which produces the direction of the magnetic needle, and all the magnetism which iron acquires by long continuance in a proper position. It is this which made us say, in the beginning of this article, that attraction and polarity were not confined to magnets, but were properties belonging to all iron in its metallic state. We now see the reason why any piece of iron brought very near to another piece will attract it—both become magnetical, in consequence of the agency of the great magnet; and their magnetism is so disposed, that their mutual attractions exceed their repulsions. Also, why an iron rod, placed nearly in the magnetical direction, will finally arrange itself in that direction. Also, why the terrestrial polarity of common iron is indifferent, and either end of the rod will settle in the north, if it have nearly that position at first. The magnetism induced by mere momentary position is so feeble as to yield to any artificial magnetism. As a moment was sufficient for imparting it, a moment suffices for destroying it; and another moment will impart the opposite magnetism. But artificial magnetism requires more force for its production, and some of it remains when the producing cause is removed, and it does not yield at once to the contrary magnetism. That there is no farther difference appears from this, that long continued position gives determined and permanent magnetism, and that it is destroyed by an equally long continuance in the contrary position. It seems to be very generally true, that a magnet will carry more by its north than by its south pole. It should be so in this part of the world, because the terrestrial magnetism induced on the iron conspires with the magnetism induced by the north pole of a magnet, but counteracts the magnetism induced by the south pole.

The propriety of Mr Savery's, Mr Canton's, and Mr Antheaume's processes for beginning the impregnation of hard steel bars is now plain, and the superior effect of the two great bars of common iron in the proposed method of Mr Antheaume. We cannot but take this opportunity of paying the proper tribute of praise to the ingenuity of Mr Savery. Every circumstance of his process was selected in consequence of an accurate conception of magnetism, and the combination of this science with Dr Gilbert's theory. His process is the same with Antheaume's in every respect, except the circumstance of the double touch borrowed from Mitchell and Canton. These observations do not detract from the discernment of Mitchell and Canton, who saw in those experiments what had escaped the attention of hundreds of readers.

68 Seeming objection deduced from the want of sensible attraction.

But there occurs an objection to this theory of Dr Gilbert, which was urged against it with great force. We observe no tendency in the magnet or compass needle toward this supposed magnet. An iron or steel bar is not found to increase its tendency downwards, that is, is not sensibly heavier, when its south pole is uppermost in this part of the world. A needle set afloat on a piece of cork arranges itself quickly in the proper direction; but if continued ever so long afloat, it has never been observed to approach the north side of the vessel. This is quite unlike, what we observe in the mutual actions of magnets, or the action of magnets on iron. This objection appears to have given Dr Gilbert some concern; and he mentions many experiments which have been tried on purpose to discover some magnetical tendency. He gets rid of it as well as he can, by saying, that the directive power of a magnet extends much farther than its attractive power. He confirms this by several experiments. But Dr Gilbert had not studied the simultaneous actions of the four poles, nor explained, by the principles of compound motion, how these produced all the possible positions of the needle. Indeed, the composition of mechanical forces was by no means familiar with philosophers at the end of the 16th century. We see it now very distinctly. The polarity of the needle, or the force with which it turns itself into the magnetical position, depends on the difference between the *sums* of the actions of each pole of the magnet on both the poles of the needle; whereas its tendency towards the magnet depends on the difference of the *differences* of those actions (see n° 22, 25.) The first may thus be very great when the other is almost insensible. We see, that coarse iron filings heap about the magnet very fast, and that very fine filings approach it very slowly. Now, the largest magnet that we can employ, when compared with the great magnet in the earth, is but as a particle of the finest filings that can be conceived. This surely diminishes exceedingly, if it does not entirely annihilate the objection: but as we

have

have heard it urged by many as an improbable thing, that a long magnet, kept afloat for many months (which has been done) shall not shew the *smallest* tendency towards the pole of the terrestrial magnet, we think it deserves to be considered with accuracy, and the question decided in a way which will admit of no doubt.

69 This completely answered. Let the very small magnet C (fig. 25.) be placed near a great magnet A, and then near a smaller magnet B, in such a manner that its polarity to both shall be the same; and then let us determine the proportion between the attractions of A and B for the small magnet C.

This will evidently depend on the law of magnetic action. For greater simplicity of investigation, we shall content ourselves with supposing the action to be inversely as the distance.

Let AN, = AS, $= a$; BN $= b$; C$n = c$, AC $= d$, BC $= \delta$; and let the absolute force of A be to that of B at the same distance as m to 1.

The magnetic action being supposed proportional to $\frac{1}{d}$, we have,

1. Action of AN on C$s = \frac{m}{d-a-c}$.

2. ——— AN on C$n = -\frac{m}{d-a+c}$.

3. ——— AS on C$s = -\frac{m}{d+a-c}$.

4. ——— AS on C$n = \frac{m}{d+a+c}$.

5. The whole action $= \frac{8macd}{\overline{d^2-\overline{a+c}|^2} \times \overline{d^2-\overline{a-c}|^2}}$.

6. If c be very small in comparison with a or b, the whole action of A is very nearly $= \frac{8macd}{\overline{d^2-a^2}|^2}$.

7. And the tendency of C to B is, in like manner, $= \frac{8bc\delta}{\overline{\delta^2-b^2}|^2}$.

The directive powers of A and B are at their maximum state when C is placed with its axis at right angles to the lines AC or BC. In which case we have,

8. The directive power of A $= \frac{4ma}{d^2-a^2}$.

9. The directive power of B $= \frac{4b}{\delta^2-b^2}$.

When these directive powers are made equal, by placing C at the proper distances from A and B, we have,

10. $4ma : 4b$, or $ma : b = d^2-a^2 : \delta^2-b^2$
And $ma\delta^2 - mab^2 = bd^2 - ba^2$
$ma\delta^2 = b(d^2-a^2) + mab^2$.

11. $\delta^2 = \frac{b}{ma}(d^2-a^2) + b^2$.

12. $\delta = \sqrt{\frac{b}{ma}(d^2-a^2) + b^2}$.

Let the attractions of A and B for the very small magnet C, when its polarity to both is the same, be expressed by the symbols α and β. We have

$\alpha : \beta = \frac{8macd}{(d^2-a^2)^2} : \frac{8bc\delta}{(\delta^2-b^2)^2}$, which, by n° 10. is $= \frac{8(d^2-a^2)cd}{(d^2-a^2)^2} : \frac{8(\delta^2-b^2)c\delta}{(\delta^2-b^2)^2} = \frac{d}{d^2-a^2} : \frac{\delta}{\delta^2-b^2}$ $= bd : ma\delta$; that is,

13. Attr^n of A : attr^n of B $= bd : ma\delta$.

As an example of this comparison, let us suppose the great terrestrial magnet to be a thousand times larger and stronger than the magnet whose attraction we are comparing with that of terrestrial magnetism. Let us also suppose the distance from the pole of the great magnet to be small, so that its attraction may be considerable. Let us make $d = 1200$, a being $= 1000$, and $b = 1$. These are all very reasonable suppositions. Substituting these values in the formula, we have attr^n of A : attr^n of B $= 1 : 1000$ very nearly; and therefore when the needle, when placed near a magnet, vibrates by its polarity as fast as it does by natural magnetism, its tendency toward that magnet must be altogether insensible; for the disproportion is incomparably greater than that of 1 to 1000, in the largest magnets with which we can make experiments. Observe also, that we have taken the case where the attractions are the strongest, viz. when the magnet C is placed in the axis of A or B. In the oblique positions, tangents to the magnetic curves, the attractions are smaller, almost in any ratio.

We took the inverse ratio of the distances for the law of action, only because the analysis was very simple. It is very evident, that the disproportion will be still more remarkable if the action be inversely as the square of the distance.

The objection therefore to the origin of the polarity of the compass needle, and of all other magnets, namely, the action of a great magnet contained in the earth, appears plainly to be of no force. We rather think that the want of all sensible attraction, where there is a brisk polarity, is a proof of the justness of the conjecture; for if the compass needle were arranged by the action of magnetic rocks, or even extensive strata, near the surface of the earth, the attractions would bear a greater proportion to the polarities. We have even observed this. A considerable mass of magnetic stratum was found to derange the needle of a surveyor's theodolite at a considerable distance all around (about 140 yards). The writer placed the needle on a thin lath, which just floated it on water in a large wooden dish, and set it in a place where it was drawn about 15 degrees from the magnetic meridian. It was left in that situation a whole night, well defended from the wind by a board laid on the dish. Next morning it was found applied to that side of the dish which was nearest to the disturbing rocks. It had moved about six inches. This was repeated three times, and each time it moved in the same direction (nearly), which differed considerably from the direction of the needle itself.

It is now plain that we may, with confidence, assume Dr Gilbert's theory of terrestrial magnetism as sufficiently established. And, since we must certainly call that the north pole of the great magnet which is situated in the northern parts of the earth, and since those poles of magnets which attract each other have opposite polarities, we must say, that what we call the north pole of a mariner's needle, or of any other magnet, has the southern polarity.

We may now venture to go farther with Dr Gilbert, and

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The great magnet is the source of all natural magnetism.

and to say that all the magnetism which we observe, whether in nature or art, is either the immediate or the remote effect of the action of the great magnet. As soft bars soon acquire a transient magnetism, as hard bars, after long exposure, acquire a sensible and permanent magnetism—we must infer, that ores of iron, which are in a state fit for impregnation, must acquire a sensible and permanent magnetism by continuing, for a series of ages, in the bowels of the earth. And thus the magnetism of loadstones, which, till the discovery of the natural magnetism acquired by position, were the sources of all our magnetical phenomena, is now proved to be a necessary consequence of the existence and agency of a great magnet contained in the bowels of the earth.

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Loadstones in the mine may have their poles in any position.

It seems to result from this theory, that, in these northern parts of the world, that part of every natural loadstone that is at the extremity of the line drawn through the stone in the magnetic direction should be its pole; and that the loadstone, when properly poised, should of itself assume the very position which it had in the mine. Dr Gilbert complains of the inattention of miners (*rude hominum genus, lucro potius quam physicæ consulentes*) to this important circumstance. Once, however, he had the good fortune to be advertised of a great magnetic mass lying in its matrix. He repaired quickly to the mine, examined it, and marked its points which were in the extremities of the magnetic line. When it was detached from its matrix, he had the pleasure of finding its poles in the very places he expected. The loadstone was of considerable size, weighing about 20 pounds.—Mr Wilcke gives in the Swedish Commentaries several instances of the same kind.

But should this always be the case? By no means. There are many circumstances which may give the magnetism of a loadstone a very different direction. We have found, that simple juxtaposition to a magnet will sometimes give a succession of poles to a long bar of hard steel. The same thing may happen to an extensive vein of magnetisable matter. The loadstone taken out of this vein may have been placed like that of a soft bar placed in the magnetic line, if lying in one part of the vein; if taken from another part of it, its polarity may be the very reverse; and in another part it may have no magnetism, although completely fitted for acquiring it. It may have its poles placed in a direction different from all these, in consequence of the vicinity of a greater loadstone. As loadstones possessed of vigorous magnetism are always found only in small pieces, and in pieces of various sizes and force, we must expect every position of their poles. The only thing that we can expect by theory is, that adjoining loadstones will have their friendly poles turned toward each other, and a general prevalence of or tendency to a polarity symmetrical with that of the earth. The reader will find some more observations to this purpose in the article VARIATION, *Encycl.* p. 623 as also in Gilbert's treatise, B. III. c. 2. p. 121.

Nor should all strata or masses of iron ore be magnetical. We know that none are susceptible of induced magnetism, but such as are, to a certain degree, in the metallic state. Such ores are not abundant. Nay, even all of such strata do not necessarily acquire magnetism by the action of the great magnet. If their principal dimensions lie nearly perpendicular to the magnetic direction, they will not acquire any sensible quantity. A stratum in this country, rising about 17 degrees to the N. N. W. will scarcely acquire magnetism. It may also happen, that the influence of the great magnet is counteracted by that of some extensive stratum inaccessible to man, by reason of its great depth.

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Probable cause of their great natural vigour.

Thus we see, that all the appearances of the original magnetism of loadstones are perfectly consistent with the notion that they are effects of one general cosmical cause, the action of the great magnet contained in the earth, and that there is no occasion to suppose this great magnet to differ, in its constitution or manner of action, from the small masses of similar matter called loadstone. The only difficulty that presents itself is the great superiority of magnetic force observable in some loadstones over other masses of ores circumjacent, which are not distinguishable by us by any other circumstance. We acknowledge ourselves unable to solve this difficulty; for the magnetism of such pieces is sometimes incomparably stronger than what a bar of iron acquires by position; yet this bar is much more susceptible than the ores which are fit for becoming loadstones. Perhaps there is some chemical change which obtains gradually in certain masses, which aids the impregnation, in the same way that we know that being red hot destroys all magnetism, whether in a metal bar or in an ore. This seems to be confirmed by what we see in some old iron stanchions, which acquire the strongest magnetism in those parts of their substance which are combining themselves with ingredients floating in the atmosphere. That part which is cased in the stone, and exfoliates and splits with rust, being converted into something like what is called finery-cinder, becomes highly and permanently magnetic. Such peculiarities as these, operating for ages, may allow a degree of magnetical impregnation (in whatever this may consist) to take place, to which we can see no resemblance in our experiments. It would be worth while to place iron wires in a tube in the magnetic direction, which could be kept of a proper red heat, while it is converted into æthiops by steam. It is not unlikely that it would acquire a sensible and permanent magnetism in this way. It may be, that the little atoms, as they arrange themselves in a sort of crystalline or symmetrical form, may also arrange so as to favour magnetism. Were this tried in the vicinity of a strong magnet, the effect might be more remarkable and precise. Perhaps, too, while iron is precipitated in a metallic form from its solutions by another metal, something of the same kind may happen. We know, that proper ores of iron, exposed to cementation in a low red heat, in the magnetic direction, becomes magnetic.

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Natural causes of the changes of the magnetic direction.

Notice has been taken in the *Encycl.* art. VARIATION, of the attempts of ingenious men to explain the change which is observed in all parts of the globe, on the direction of the mariner's needle, the gradual change of the variation. The hypothesis of Dr Halley, that the globe which we inhabit is hollow, and incloses a magnetic nucleus, moving round another axis, is not inconsistent with any natural law, if he did not suppose the interval filled up with some fluid. The action of the nucleus and shell on the intervening fluid would gradually bring the two to one common motion of rotation, as may be inferred from the reasonings employed by Newton in his remarks on the Cartesian vortices.

Leaving

Leaving out this circumſtance, there is only another cauſe which can affect, and muſt affect, the rotation of both; namely, the mutual action of the magnetic nucleus, and the maſſes of magnetic matter in the ſhell. If the axis of rotation of this nucleus be different from the line joining its magnetic poles, theſe poles will have a motion relative to the ſhell; and this motion may eaſily be conceived ſuch as will produce the changes of magnetic direction which we obſerve. It may even produce a motion of the northern magnetic pole in one direction, and of the ſouthern pole in the oppoſite direction, and this with the appearance of different periods of rotation, as ſuppoſed by Mr Churchman. We may here obſerve, by the way, that the change of magnetic direction in this country is not nearly ſo great as is commonly imagined. The horizontal needle has ſhifted its poſition about 35° at London ſince 1585; but the point of the dipping needle has not changed 10°. We may alſo obſerve, that when the pole of the central magnet changes its place, the magnetiſm of an extenſive ſtratum, influenced by it, may ſo alter its diſpoſition, as to change the poſition of the compaſs needle in the oppoſite direction to that of the change which the central magnet alone would induce on it.

But as motions have not yet been aſſigned to this nucleus, which quadrate with the obſerved poſitions of the needle, and as the very exiſtence of it is hypothetical, it may not be amiſs to examine, whether ſuch a change of variation may not be explained by what we know of the laws of magnetiſm, and of the internal conſtitution of this earth?

1. It is pretty certain, that the veins in which loadſtones are found are not parts of the great magnet. This appears from their having two poles while in the mine, and alſo from the very ſmall depth to which man has been able to penetrate. When we compare the poſitions of the dipping needle with thoſe of a ſmall needle near a magnet, we muſt infer, that the poles are very far below the ſurface.

Yet we know, that there are magnetiſable ſtrata of very great extent occupying a very conſiderable portion of the external covering. Though their bulk and abſolute power may be ſmall, when compared with thoſe of the great magnet, yet their greater vicinity to the needles on which obſervations are made, may give them a very ſenſible influence. In this way may a great deal of the obſerved irregularities of the poſitions of the needle be accounted for. In the Lagoon at Teneriffe, *Feuillée* obſerved the variation 13° 30′ weſt in 1724, while at the head of the iſland it was only 5°. The dip at the Lagoon was 63° 30′, greatly ſurpaſſing what was obſerved in the neighbourhood. Muller found, in the mountains of Bohemia, great and deſultory differences of declination, amounting ſometimes to 50′. At Mantua, the variation in 1758 was 12°; while at Bononia and Brixia it was nearly 18°. Great irregularities were obſerved by Goëte in the Gulph of Finland, eſpecially near the iſland of Suſſari, among ſome rocks: on one of theſe, the needle ſhewed no polarity. Captain Cook and Captain Phipps obſerved differences of 10°, extending to a conſiderable diſtance, on the weſt coaſts of North America. In the neighbourhood of the iſland Elba in the Mediterranean, the poſition of the needle is greatly affected by the iron ſtrata, in which that iſland ſo much abounds. In this country, there are alſo obſerved ſmall deviations which extend over conſiderable tracts of country, indicating a great extent of ſtrata that are weakly magnetic. Since ſuch ſtrata receive their magnetiſm by induction, in a manner ſimilar to a bar of hard ſteel, and ſince we know that this receives it gradually, it may very probably happen, that a long ſeries of years may elapſe before the magnetiſm attains its ultimate diſpoſition.

Here, then, is a neceſſary change of the magnetic direction; and although it may be very different in different places, according to the diſpoſition and the power of thoſe ſtrata, there muſt be a general vergency of it one way.

2. It is well known that all metals, and particularly iron, are in a progreſs of continual production and demetallization. The veins of metals, and more particularly thoſe of iron, are evidently of poſterior date to that of the rocks in which they are lodged. Chemiſtry teaches us, by the very nature of the ſubſtances which compoſe them, that they are in a ſtate of continual change. This is another cauſe of change in the magnetic direction. Nay, we know that ſome of them have ſuddenly changed their ſituation by earthquakes and volcanoes. Some of the ſtreams of lava from Veſuvius and Ætna abound in iron. This has greatly changed its ſituation; and if the ſtrata from which it proceeded were magnetical, the needle in its neighbourhood muſt be affected. Nay, ſubterranean heat alone will effect a change, by changing the magnetiſm of the ſtrata. Mr Lievog, royal aſtronomer at Beſſeſtedt in Iceland, writes, that the great eruption from Hecla in 1783, changed the direction of the needle nine degrees in the immediate neighbourhood. This change was produced at a mile's diſtance from the frozen lava; and it diminiſhed to two degrees at the diſtance of 2½ miles. He could not approach any nearer, on account of the heat ſtill remaining in the lava, after an interval of 14 months.

All theſe cauſes of change in the direction of the mariner's needle muſt be partial and irregular. But there is another cauſe, which is coſmical and univerſal. Dr Halley's ſuppoſition of four poles, or, at leaſt, the ſuppoſition of irregular and diffuſed poles, ſeems the only thing that will agree with the obſervations of declination. We know that all magnetiſm of this kind (that is, diſpoſed in this manner) has a natural tendency to change. The two northern poles may have the ſame or oppoſite polarities. If they are the ſame, their action on each other tends to diminiſh the general magnetiſm, and to cauſe the centre of effort to approach the centre of the magnet. If they have oppoſite polarities, the contrary effect will be produced. The general magnetiſm of each will increaſe, and the pole (or its centre of effort) will approach to the ſurface. In either of theſe caſes, the compound magnetiſm of the whole may change exceedingly, by a change by no means conſiderable in the magnetiſm of each pair of poles. It is difficult to ſubject this to calculation; but the reader may have very convincing proof of it, by taking a ſtrong and a weaker magnet of the ſame length, and one of them, at leaſt, of ſteel not harder than ſpring temper. Lay them acroſs each other like an acute letter X, and then place a compaſs needle, ſo that its plane of rotation may be perpendicular to the plane of the X. Note exactly the poſition in which the needle ſettles. In a few minutes after, it will be found to change conſiderably,

siderably, although no remarkable change has yet happened to the magnets themselves.

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74 Speculations about the origin of magnetism. Hypothesis of Æpinus.

We flatter ourselves, that our readers will grant that the preceding pages contain what may justly be called a theory of magnetism, in as much as we have been able to include every phenomenon in one general fact, the induction of magnetism; and have given such a description of that fact and its modifications, that we can accurately predict what will be the appearances of magnets and iron put into any desired situation with respect to each other. If our notions of philosophical disquisition (delivered in art. PHILOSOPHY, *Encycl. Brit.*) be just, we have explained the subordinate phenomena, or have given a theory of magnetism.

But it is not easy to satisfy human curiosity. Men have even investigated, or sought for causes of the perseverance of matter in its present condition. We have not been contented with Newton's theory of the celestial motions, and have sought for the cause of that mutual tendency which he called gravitation, and of which all the motions are particular instances.

Philosophers have been no less inquisitive after what may be the cause of that mutual attraction of the dissimilar poles, and the repulsion of the similar poles, and that faculty of mutual impregnation, or excitement, which so remarkably distinguish iron, in its various states, from all other substances. The action of bodies on each other at a distance, has appeared to them an absurdity, and all have had recourse to some material intermedium. The phenomenon of the arrangement of iron filings is extremely curious, and naturally engages the attention. It is hardly possible to look at it without the thought arising in the mind of a stream issuing from one pole of the magnet, moving round it, entering by the other pole, and again issuing from the former outlet. Accordingly, this notion has been entertained from the earliest times, and different speculatists have had different ways of conceiving how this stream operated the effects which we observe.

The simplest and most obvious was just to make it act like any other stream of fluid matter, by impulsion. Impulsion is the thing aimed at by all the speculatists. They have a notion, that we conceive this way of communicating motion with intuitive clearness, and that a thing is fully explained when it can be shewn that it is a case of impulsion. We have considered the authority of these explanations in the article IMPULSION of this *Supplement*, and need not repeat our reasons for refusing it any pre eminence. But even when we have shewn the phenomena to be cases of impulsion by such a stream, the greatest difficulty, the most curious and the most embarrassing, is to ascertain the sources of this impulsive motion of the fluid—How, and from what cause does it begin? What forces bend it in curves round the magnet? Those philosophers, whose principle obliges them to explain gravitation also by impulse, must have another stream to impel this into its curves. Acting by impulsion, this magnetic stream must lose a quantity of motion equal to what it communicates. What is to restore this? What directs it in a particular course thro' the magnet? And what is it that can totally alter that course—in a moment—in all the phenomena of induced magnetism? How does it impel? Lucretius, either of himself, or speaking after the Greek philosophers, makes it impel, not the iron, but the surrounding air, sweeping it out of the way; and thus giving occasion for the surrounding air to rush around the magnet, and to hurry the bits of iron toward it. There is, perhaps, more ingenious refinement in this thought than in any of the impulsive theories adopted since his day by Des Cartes, Euler, and other great philosophers: But it is sagaciously remarked by D. Gregory, in his MS. notes on Newton, that this theory of Lucretius falls to the ground; because the experiments succeed just as well under water as in the air. As to the explanations, or descriptions, of the canals and their dock gates, opening in one direction, and shutting in the other, constructions that are changed in an instant in a bar of iron, by changing the position of the magnet, we only wonder that men, who have a reputation to lose, should ever hazard such crude and unmechanical dreams before the public eye. The mind of man cannot conceive the possibility of their formation; and if they are really formed, the effects should be the very opposite of those that are observed: the stream should move those bodies least which afford ready channels for its passage. If a rag of iron filings be arranged by the impulsion of such a stream, it should be carried along by it; and if it is *impelled toward* one end of the magnet, it should be impelled *from* the other end. Since we now know, that each particle of filings is a momentary magnet, we must allow a similar stream whirling round each. Is that an explanation which exceeds all power of conception?

But has it ever been shewn, that there is any impulsion at all in these phenomena? Where is the impelling substance? The only argument ever offered for its existence is, that we are resolved that the phenomena of magnetism shall be produced by impulsion, and the arrangement of iron filings looks somewhat like a stream. But enough of this. We trust that we have shewn the way in which this arrangement obtains in the clearest manner. Every particle becomes magnetic by induction. This is a fact, which sets all reasoning at defiance. The polarity of each rag is so disposed, that their adjoining ends turn to each other. This is another uncontrovertible fact. And these two facts explain the whole. The arrangement of iron filings, therefore, is a secondary fact, depending on principles more general; and therefore cannot, consistently with just logic, be assumed as the foundation of a theory.

Had magnetism exhibited no phenomena besides the attraction and repulsion of magnets, it is likely that we should not have proceeded very far in our theories, and would have contented ourselves with reducing these phenomena to their most general laws. But the communication of magnetism seems a great mystery. The simple approach of a magnet communicates these powers to a piece of iron; and this without any diminution of its own powers. On the contrary, beginning with magnets which have hardly any sensible power, we can, by a proper alternation of the manipulations, communicate the strongest magnetism to as many hard steel bars as we please; and the original magnets shall be brought to their highest degree of magnetism. We have no notion of powers or faculties, but as qualities of some substances in which they are inherent. Yet here is no appearance of something abstracted from one body, and communicated to, or shared with another. The process is like kindling a great fire by a simple spark; here

is no communication, but only *occasion* given to the exertion of powers inherent in the combustible matter. It appears probable, that the case is the same in magnetism; and that all that is performed in making a magnet is the excitement of powers already in the steel, or the giving occasion for their exertion; as burning the thread which ties together the two ends of a bow, allows it to unbend. This notion did not escape the sagacity of Dr Gilbert; and he is at much pains to shew, that the *coitio magnetica* is a quality inherent in all magnetical bodies, and only requires the proper circumstance for its exertion. He is not very fortunate in his attempts to explain *how* it is developed by the vicinity of a magnet, and how this faculty, or actual exertion of this power, becomes permanent in one body, while in another it requires the constant presence of the magnet.

74 It is to Mr Æpinus, of the Imperial Academy of St Petersburgh, that we are indebted for the first really philosophical attempt to explain all these mysteries. We mentioned, in the article Electricity, *Suppl.* the circumstance which suggested the first hint of this theory to Æpinus, *viz.* the resemblance between the attractions and repulsions of the tourmaline and of a magnet. A material cause of the electric phenomena had long been thought familiar to the philosophers. They had attributed them to a fluid which they called an electric fluid, and which they conceived to be shared among bodies in different proportions, and to be transferable from one to another. Dr Franklin's theory of the Leyden phial, which led him to think that the faculty of producing the electrical phenomena depended on the deficiency as well as the redundancy of this fluid, combined with the phenomena of induced electricity, suggested to Æpinus a very perspicuous method of stating the analogy of the tourmaline and the magnet; which he published in 1758 in a paper read to the academy.

Reflecting more deeply on these things, Mr Æpinus came by degrees to perceive the perfect similarity between all the phenomena of electricity by position and those of magnetism; and this led him to account for them in the same manner. As the phenomena of the Leyden phial, explained in Franklin's manner, shews that a body may appear electrical all over, by having less than its natural quantity of the electric fluid, as well as by having more, it seemed to follow, that it may also be so in respect to different parts of the same body; and therefore a body may become electrified in opposite ways at its two extremities, merely by abstracting the fluid from one end, and condensing it in the other; and thus may be explained the phenomena of induced electricity, where nothing appears to have been communicated from one body to the other. If this be the case, the two ends of a body rendered electric by induction should exhibit the same distinctions of phenomena that are exhibited by bodies wholly redundant and wholly deficient. The redundant ends should repel each other; so should the deficient ends; and a redundant part should attract a deficient. All these results of the conjecture tally exactly with observation, and give a high degree of probability to the conjecture. The similarity of these phenomena to the attractions of the dissimilar poles of a magnet, and the repulsions of the similar poles, is so striking, that the same mode of explanation forces itself on the mind, and led Mr Æpinus to think, that the faculty of producing the magnetical phenomena belonged to a magnetical fluid, residing in all bodies susceptible of magnetism; and that the exertion of this faculty require nothing but the abstraction of the fluid from one end of the magnetic bar, and its constipation in the other. And this conjecture was confirmed by observing, that in the induction of magnetism on a piece of iron, the power of the magnet is not diminished.

All these circumstances led Mr Æpinus to frame the following hypothesis:

1. There exists a substance in all magnetic bodies, which may be called the magnetic fluid; the particles of which repel each other with a force decreasing as the distance increases.

2. The particles of magnetic fluid attract, and are attracted by the particles of iron, with a force that varies according to the same law.

3. The particles of iron repel each other according to the same law.

4. The magnetic fluid moves, without any considerable obstruction, through the pores of iron and soft steel; but is more and more obstructed in its motion as the steel is tempered harder; and in hard tempered steel, and in the ores of iron, it is moved with the greatest difficulty.

In consequence of this supposed attraction for iron, the fluid may be contained in it in a certain determinate quantity. This quantity will be such, that the accumulated attraction of a particle for all the iron balances, or is equal to, the repulsion of all the fluid which the iron contains. The quantity of fluid competent to a particle of iron is supposed to be such, that the repulsion exerted between it and the fluid competent to another particle of iron is also equal to its attraction for that particle of iron: And therefore the attraction between the fluid in an iron bar A for the iron of another bar B, is just equal to its repulsion for the fluid in B; it is also equal to the repulsion of the iron in A for the iron in B. This quantity of fluid residing in the iron may be called its NATURAL QUANTITY.

In consequence of the mobility through the pores of the iron, the magnetic fluid may be abstracted from one end of a bar, and condensed in the other, by the agency of a proper external force. But this is a violent state. The mutual repulsion of the particles of condensed fluid, and the attraction of the iron which it has quitted, tend to produce a more uniform distribution. If we reflect on the law of action, we shall clearly perceive, that somewhat of this tendency must obtain in every state of condensation and rarefaction, and that there can be a perfect equilibrium only when the fluid is diffused with perfect uniformity. This, therefore, may be called the NATURAL STATE of the iron.

If the resistance opposed by the iron to the motion of the magnetic fluid be like that of perfect fluids to the motion of solid bodies, arising entirely from the communication of motion, there is no tendency to uniform diffusion so weak as not to overcome such resistance, and finally to produce this uniform distribution. But (as is more probable) if the obstruction resembles that of a clammy fluid, or of a soft plastic body like clay, some of the accumulation, produced by the agency of an external force, may remain when the force is removed; the diffusion will cease whenever the equalising force is just in equilibrio with the obstruction.

All the preceding circumstances of the hypothesis are

are so perfectly conformable to the hypothesis of Mr Æpinus for explaining the electrical phenomena, which is given in detail in the article Electricity of this *Supplement*, that it would be superfluous to enter into a minute discussion of their immediate results. We therefore beg the reader to peruse that part of the article Electricity where the elements of Æpinus's hypothesis are delivered, and the phenomena of induced electricity explained (see from n° 11. to 63. inclusive), and to suppose the discourse to relate to the *magnetical* fluid. Let N, S, *n*, *s*, be considered as the overcharged and undercharged parts of a magnetical body, or the poles of a magnet, and of iron rendered magnetical by induction. We shall confine our observations in this place to those circumstances in which the mechanical phenomena of magnetism are limited by the circumstance, that magnets always contain their natural quantity of fluid; so that their action on iron, and on each other, depends entirely on its unequable distribution; as is the case with induced electricity.

Magnetism induced on iron. Let the magnet NAS (fig. 26.), having its north pole NA overcharged, be set near to the bar *n* B *s* of common iron, and let their axes form one straight line. Then (as in the case of electrics) the overcharged pole NA acts on the bar B only by means of the redundant fluid which it contains. For that portion of its fluid, which is just sufficient for saturating the iron, will repel the fluid in B, just as much as the iron in NA attracts it; and therefore the fluid in B sustains no change from this portion of the fluid in NA. In like manner, the pole SA acts on B only in consequence of the iron in SA, which is not saturated or attended by its equivalent fluid.

If the fluid in B is immoveable, even the redundant fluid in NA, and redundant iron in SA, will produce no *sensible* effect on it: For every particle of iron in B is accompanied by as much fluid as will balance, by its repulsions and attractions, the attractions and repulsion of the coincidant particle of iron. But as the magnetical fluid in B is supposed to be easily moveable, it will be repelled by the redundant fluid in AN toward the remote extremity *n*, till the resistance that it meets with, joined to its own tendency to uniform diffusion, just balances the repulsion of AN. This tendency to uniform diffusion obtains as soon as any fluid quits its place; as has been sufficiently explained in the Supplementary article Electricity, n° 16. 17. &c.)

But, at the same time, the redundant iron in AS attracts the fluid in B, and would abstract it from B *n*, and condense it into B *s*. This attraction opposes the repulsion now mentioned. But, because AS is more remote from every point of B than AN is from the same point, the repulsions of the redundant fluid in AN will prevail; and, on the whole, fluid will be propelled toward *n*, and will be rarefied on the part B *s*. But as to what will be the law of distribution, both in the redundant and deficient parts of B, it is plain that nothing can be said with precision. This must depend on the distribution of the fluid in the magnet NAS. The more diffused that we suppose the redundant fluid and matter in the magnet, the farther removed will the centres of effort of its poles be from their extremities; the smaller will be the action of AN and AS, the smaller will be their difference of action; and therefore the smaller will be the condensation in B *n*, and the rarefaction in B *s*. Hence we learn, at the outset of this attempt to explanation, that the action of a magnet will be so much the greater as its poles are more concentrated. This is agreeable to observation, and gives some credit to the hypothesis. We can judge, in a very general manner, that the fluid will be rarer than its natural state in *s*, and denser in *n*; and that the change of density is gradual, and that the density may be represented by the ordinates of some line *c b d* (fig. 27.), while the natural density is represented by the ordinates to the line C *b* D, parallel to *s n*. There will be some point B of the iron bar, where the fluid will be of its natural density, and the ordinate B *b* will meet the line *c b d* in the point of its intersection with CD.

All this action is internal and imperceptible. Let us inquire what will be the *sensible* external action. There is a superiority of attraction towards the magnet: For since the magnetic action is supposed to diminish continually by an increase of distance, the curve, whose ordinates represent the forces, has its convexity toward the axis. Also, the force of the poles AN, AS are equal at equal distances: For, by the hypothesis, the attraction and repulsion of an individual particle are equal at equal distances; and the condensation in AN is equal to the deficiency in AS, by the same hypothesis; because NAS still contains its natural quantity of fluid. Therefore the action of both poles may be expressed by the ordinates of the same curve, and they will differ only by reason of their distances. We may therefore express the actions by the four ordinates M *m*, P *p*, N *n*, Q *q*, of fig. 2; of which the property (deduced from the single circumstance of its being convex toward the axis) is, that M *m* + Q *q* is greater than P *p* + N *n*. There is therefore a surplus of attraction. It is only this surplus that is perceived. The fluid, moveable in B, but retained by it so as not to be allowed to escape, is pressed towards its remote end *n*, by the excess P *p* — Q *q* of the repulsion of the redundant fluid in AN, above the attraction of the redundant iron in AS. This excess on every particle of the fluid is transmitted, by the common laws of hydrostatics, to the stratum immediately incumbent on the extremity *n*, and B is thus pressed away from A. But every particle of the solid matter in B is attracted towards A by the excess M *m* — N *n* of the attraction of the redundant fluid in AN above the repulsion of the redundant iron in AS: and this excess is greater than the other; for *m* + *q* is greater than *p* + *n*.

The piece of common iron *n* B *s* is therefore attracted, *in consequence* of the fluid in it having been propelled towards its remote extremity, and distributed in a manner somewhat resembling its distribution in NAS. Now, in this hypothesis, magnetism is held to depend entirely on the distribution of the fluid. B has therefore become a magnet, has magnetism induced on it, and, only in consequence of this induction, is attracted by A.

Had we supposed the deficient, or south pole of A, to have been nearest to B, the redundant matter in AN would have attracted the moveable fluid in B more than the remoter redundant fluid in AS repels it; and, on this account, the magnetic fluid would have been constipated in B *s*, and rarefied in B *n*. It would, in this case also, have been distributed in a manner similar to its

its situation in the magnet. And B would therefore have been a momentary magnet, having its redundant pole fronting the deficient or dissimilar pole of A. It is plain, that there would be the same surplus of attraction in this as in the former instance, and B would (on the whole) be attracted in consequence, and only in consequence, of having had a properly disposed magnetism induced on it by juxtaposition. The sensible attraction, in this case, is a *consequence* of the distribution now described; because, since the fluid constipated in the end next to A cannot quit B, the tendency of this fluid toward A must press the solid matter of B in this direction (by hydrostatical laws) more than this solid matter is repelled in the opposite direction.

Thus it appears, that the hypothesis tallies precisely with the induction of magnetism. We do not call this an explanation of the phenomenon; for the fact is, that it is the hypothesis that is explained by the phenomenon: That is, if any person be told that induced magnetism is produced by the action of a fluid, in consequence of its situation being changed, he will find, that in order to agree with the attraction of dissimilar, and the repulsion of similar poles, he must accommodate the fluid to the phenomena, by giving it the properties assigned to it by Æpinus.

76 Conformity of the hypothesis with a vast variety of phenomena.

But the agreement with this simplest possible case of the most simple example of induced magnetism, is not enough to make us adopt the hypothesis as adequate to the explanation of all the magnetic phenomena. We must confront the hypothesis with a variety of observations, to see whether the coincidence will be without exception.

When the key CB, in fig. 8. is brought below the constipated north pole N of the magnet SAN, its own moveable fluid is propelled *from* C towards B, and is disposed in CB nearly after the same manner as in SAN. Therefore the redundant fluid in the lower end of the key repels the moveable fluid in the wire BD more than the redundant matter in the upper end C attracts it; and thus the fluid is rarefied in the upper end of the wire BD, and condensed in its lower end D. CB and BD therefore are two temporary magnets, having their dissimilar poles in contact, or nearest to each other. This is all that is required for their attraction. This effect is promoted by the action of N on the wire BD, also propelling the fluid toward D; and thus increasing the mutual attraction of CB and BD. In like manner, when the key CB is held above the magnet, the moveable fluid in it is more attracted by the redundant matter in SA than it is repelled by the more remote redundant fluid in AN. The same thing happens to the fluid in the wire BD. Therefore CB and BD must attract each other; and the key will carry the wire, although the magnet is below it, and also attracts it. This singularity proceeds from the almost perfect mobility of the fluid in the two pieces of common iron, which renders their poles extremely constipated; whereas the hardness required for the fixed magnetism of the magnet prevents this complete constipation and rarefaction. This can be strictly demonstrated in the case of slender rods of iron; but we can shew, and experience confirms it, that in other cases, depending on the shape and the temper of the pieces, the wire will not adhere to the key, but to the magnet.

In the various situations and position of the key and wire represented in fig. 7. the actions of some of the poles on the moveable fluid in the iron are oblique in regard to the length of the pieces; but, since the moveable matter is supposed to be a fluid, it will still be propelled along the pieces, notwithstanding their obliquity, in the same manner as gravity makes water occupy the lower end of a pipe lying obliquely. If indeed the magnetic fluid could escape from the iron without any obstruction by the propulsion of the magnet, it could produce no attraction, or sensible motion, any more than light does in a transparent body. What is demonstrated of the electric fluid in the Supplemental article ELECTRICITY, n° 133. is equally true here. Why the fluid does not escape when it is so perfectly moveable, is a question of another kind, and will be considered afterwards; at present, the *hypothesis* is, that it does not escape.

If the key and wire have the position fig. 10 n° 1. the fluid is expelled from the parts in contact, and is condensed in the remote ends. So far from attracting each other, the key and wire must repel. They are temporary magnets, having their similar poles fronting each other. They must repel each other, if presented in a similar manner to the south pole of the magnet.

If they be presented as in n° 2. fig. 10. where the actions of both poles of the magnet are equal, the state of the fluid in them will not be affected. The redundant pole of the magnet repels the moveable fluid in both the key and the wire toward the upper ends; but the deficient pole acts equally on it in the opposite direction. It therefore remains uniformly distributed through their substance; and therefore they can exhibit no appearance of magnetism.

But if the key and wire be presented to the *same* part of the magnet, but in another position, as shewn in fig. 8. n° 3. the fluid of the key will be abstracted from C, and condensed in B, by the joint action of both poles of the magnet. The same thing will happen in the wire BD. Here, therefore, we have two magnets with their dissimilar poles touching. They will attract each other strongly; and if carried gradually toward the upper or lower end of the magnet, they will separate before the point B arrives abreast of N or S. For similar reasons, the pieces of iron presented to the middle of the magnet, as in fig. 10. will have one side a weak north pole, and the other side a weak south pole; but this will not be conspicuous, unless the pieces be broad.

This experiment shews, in a very perspicuous manner, the competency of the hypothesis to the explanation of the phenomena. When the fluid is not moved, magnetism is not induced, even on the most susceptible substance.

When a piece of iron A (fig. 10.), nearly as large as the magnet can carry, hangs at either pole, a large piece of iron B, brought near to the pole on the other side, should cause it immediately to fall. If S be the deficient pole, it causes the fluid in A to ascend to the top, and A is attracted: but, for the same reason, it causes the fluid in B to accumulate in its lower end. This redundant fluid must evidently counteract the redundant matter in S, in the induction of the magnetic state on A. Being more remote from A than S is, it cannot wholly prevent the accumulation in the upper end of A; but it renders it so trifling, that the remaining

attraction thence arising cannot support the weight of A. This is a very instructive experiment.

But if, on the contrary, we bring a large piece of iron C below the heavy key A, this piece C will have its fluid accumulated in its upper end, both by the action of A on it, and by the action of the magnet. The attraction of the magnet for A should therefore be augmented; and a magnet should carry a heavier lump of iron when a great lump is beyond it. And it is clear (we think), for similar reasons, that the magnetism of the magnet itself in fig. 11. should be increased by bringing a great lump of iron near its opposite pole: for the magnet differs from common iron only in the *degree* of the mobility of its fluid.

When a compass needle is placed opposite to the redundant pole N of a magnet AN (fig. 28.), it arranges itself magnetically. If a piece of common iron be now presented laterally to the near point of the needle, the redundant matter in the adjoining parts of the needle and the iron should make them repel; but if presented to the remote end, the redundant matter in the iron should attract the redundant fluid in that end of the needle, and that end should turn toward the iron.

A parcel of slender iron wires, carried by the pole of a magnet, as in fig. 29 should avoid each other. If N be the redundant pole, the fluid in each wire will be driven to the remote end, where it must repel the similarly situated fluid of its neighbour. The same external appearance must be exhibited by pieces of wire hanging at the deficient pole of the magnet.

The redundant pole of a magnet A (fig. 30.) being held vertically above the centre of two pieces of common iron, moveable round a slender pin, renders the middle of each deficient, and their extremities redundant; therefore they should repel each other, and spread out. The same effect should be produced by the under charged pole of A.

The redundant pole of a magnet A being applied to one branch of the piece of forked iron NCS (fig. 31.), should drive the fluid into its remote parts C, and then the branch NC should be able to induce the magnetic state on a bit of iron D. But if the deficient pole S of another magnet B be applied to the other branch, these two actions should counteract each other at C; and the iron should remain indifferent, and fall.—Yet the magnet B alone would equally cause C to carry the piece of iron.

It is surely unnecessary to demonstrate, that the consequence of this hypothesis must be, that when a magnet puts any piece of iron into the magnetic state, its own magnetism is improved. For the induced magnetism of the iron is always so disposed as to give the fluid in the magnet a greater constipation where already condensed, and to abstract more fluid from the parts already deficient. If magnetism be produced by such a fluid, a magnet must always improve by lying any how among pieces of iron.

But the case may be very different when magnets are kept in each others neighbourhood. When the overcharged poles of two magnets are placed fronting each other, the redundant fluid in each repels that in the other more than it attracts the remoter redundant iron. The magnets must therefore repel each other. Moreover, in rendering them magnetical, the repulsion of redundant fluid, or the attraction of redundant matter of some other magnet, had been employed; and when the magnet was removed, some of the constipated fluid overcame the obstruction to its uniform diffusion, and escaped into the deficient pole; what remains is withheld by the obstruction, and the restoring forces are just in equilibrio with this obstruction. If we now add to them the repulsion of redundant fluid, directed toward the deficient pole, some more of the constipated fluid must be driven that way, and the magnet must be weakened. Nay, it may be destroyed, and even reversed, if one of the magnets be very powerful, and have its own magnetism very fixed; that is, if its fluid be very redundant, and meet with very great obstruction to its motion. Hence it also should follow, that the repulsion observed between two magnets should be weaker at the same distance than their attraction, and should follow a different law. For, in the course of the experiments, the situation of the fluid in the magnets is continually changing, and approaching to a state of uniform diffusion.

Let us now examine into the sensible effect of this fluid on a magnet which cannot move from its place, but can turn on its centre like a compass needle. This scarcely requires any discussion. We should only be repeating, with regard to the redundant fluid and redundant matter, what we formerly said in regard of north pole and south pole; the little magnet must arrange itself nearly in the tangent of a magnetic curve. But it requires a more minute investigation to determine what the sensible phenomenon should be when the fluid of the little magnet is perfectly moveable. 77 Explanation of the directive power, and of polarity.

Suppose therefore a particle C (fig. 32.) of magnetic fluid, at perfect liberty to move in every direction, and acted on by the redundant and deficient poles of a magnet NAS. The redundant iron in S attracts C in the direction and with the force CF, while the redundant fluid in N repels it in the direction and with the force CD. By their joint action it must be urged in the direction and with the force CE, the diagonal of the parallelogram CDEF, which must be accurately a tangent to a magnetic curve. If this particle of fluid belong to the piece of iron nCs, which lies in that very direction, it will unquestionably be pushed towards the extremity n. The same must happen to other particles. Hence it appears that a piece of common iron in this situation and position must become a magnet, and must retain this position; only the mechanical energy of the lever may change the equilibrium of the magnetic forces a little; because when the piece of iron nCs has any sensible magnitude, the action on its different points will be a little unequal, and may compose diagonals which divide a little from the tangent.

Should the iron needle chance not to have the exact position, but not deviate very far from it, it is also clear that the fluid, not being able to escape, will press on the side toward which it is impelled; and thus will cause the needle to turn on its pivot, and finally arrange itself in magnetical and mechanical equilibrium, deviating so much the less from a tangent to a magnetic curve as the piece of iron is smaller. Any piece of common iron, held in the neighbourhood of a magnet, will become more overcharged at one end and undercharged at the other, in proportion as the position of its length comes nearer to the tangent of a magnetic curve. A slender wire held perpendicular to this position, that

is, perpendicular to the curve, ſhould not acquire any ſenſible magnetiſm, either attractive or directive.

78 Explanation of the curves formed by iron filings

We ſurely need not now employ many words to ſhew that a parcel of iron filings, ſtrewed round a magnet, ſhould arrange themſelves in the primary magnetic curves, or that when ſtrewed round two magnets they ſhould form the ſecondary or compoſite curves.

79 Explanation of tranſitory and of permanent magnetiſm, and of indifferent and determinate magnetiſm.

Let us now enquire more particularly into the modifications of this accumulation of magnetic fluid which may reſult from the nature of the piece of iron, as it is put into the magnetic ſtate. The propelling force of A acts againſt the mutual repulſion of the particles of fluid in B, and alſo againſt the obſtruction to its motion through the pores of B. The greater this obſtruction, the ſmaller will be the accumulation which ſuffices, in conjunction with the obſtruction and the attraction of the deſerted iron, to balance the propulſive force of the redundant fluid in the overcharged pole of A. This circumſtance therefore muſt limit the accumulation that can be produced in a given time. Therefore the magnetiſm produced on ſoft ſteel or iron ſhould be greater than that produced in hard ſteel at the ſame diſtance. Hence the great advantage of ſoft poles, or of armour, or of capping, to a loadſtone, or to a bundle of hard bars. The beſt form and dimenſions of this armour is certainly determinable by mathematical principles, if we knew the law of magnetical action, and the diſpoſition of the magnetiſm in our loadſtone; but theſe are too imperfectly known in all caſes for us to pretend to give any exact rules. We muſt decide experimentally by making the caps large at firſt, and reducing them till we find the loadſtone carry leſs; then make them a ſmall matter larger. The chief things to be minded are the purity, the uniformity, and the ſoftneſs of the iron, and the cloſeſt poſſible contact.

If the obſtruction reſemble that to motion through a clammy fluid, the final accumulation in hard ſteel may be nearly equal to that in iron, but will require much longer time. Alſo, becauſe ſuch obſtruction to the motion of the fluid will nearly balance the propelling force in parts that are far removed from the magnet, the accumulation will begin thereabouts, while the bar beyond is not yet affected. A redundant pole will be formed in that place. This will operate on what is *immediately* beyond it, driving the fluid farther on, and occaſioning another accumulation at a ſmall diſtance. This may produce a ſimilar effect in a ſtill ſmaller degree farther on. Thus the ſteel bar will have the fluid alternately condenſed and rarefied, and contain alternate north and ſouth poles. This ſtate of diſtribution will not be permanent; fluid will be gradually changing its place; theſe poles will gradually advance along the bar, the remoter poles becoming gradually more diffuſe and faint; and it will not be till after a very long time that a regular magnetiſm with two poles will be produced. To ſtate mathematically the procedure of this mechaniſm would require many pages. Yet it may be done in ſome ſimple caſes, as Newton has ſtated the proceſs of aerial undulation. But we cannot enter upon the taſk in this limited diſſertation. What is ſaid in the Supplementary article ELECTRICITY (n° 217, 218.) on the diſtribution of the electric fluid in an imperfect inſulator, will aſſiſt the reader to form a notion of the ſtate of magnetiſm during its induction. That ſuch alternations proceed from ſuch mechaniſm, we have ſufficient proof in the inſtances mentioned in the former part of this article. The wave, or curl, produced on the ſurface of a clammy fluid, is a phenomenon of the ſame kind, and owing to ſimilar cauſes.

When the magnet which has produced all theſe changes is removed, it is evident that a part of this accumulation will be undone again. The repulſion of the condenſed fluid, and the attraction of the deſerted iron, will bring back ſome of the fluid. But it is very evident, that a part of the accumulation will remain, by reaſon of the obſtruction to its motion in returning; and this remainder muſt be ſo much the greater as the obſtruction to the change of ſituation is greater. In ſhort, we cannot doubt but that the magnetiſm which remains will be greater in hard than in ſpring tempered ſteel.

80 Rationale of the rules for making magnets.

Thus have we traced the hypotheſis in a great variety of circumſtances and ſituations, and pointed out what ſhould be the external appearance in each. We did not, in each inſtance, mention the perfect coincidence of theſe conſequences with what is really obſerved, but left it to the recollection of the reader. The coincidence is indeed ſo complete, that it ſeems hardly poſſible to refuſe granting that nature operates in this or ſome very ſimilar manner. We get ſome confidence in the conjecture, and may even proceed to explain complicated phenomena by this hypothetical theory. We might proceed to ſhew, that the effects of all the methods practiſed by the artiſts in making artificial magnets are eaſy conſequences of the hypotheſis: but this is hardly neceſſary. We ſhall juſt mention ſome facts in thoſe proceſſes which have puzzled the naturaliſts.

1. A ſtrong magnet is known to communicate the greateſt magnetiſm to a bar of hard ſteel; but Muſchenbroek frequently found, that a weak magnet would communicate more to a ſoft than to a hard bar.

Explanation. When the magnet is ſtrong enough to impregnate both as highly as they are capable of, the hard bar muſt be the ſtrongeſt; but if it can ſaturate neither, the ſpring-tempered bar muſt be left the moſt magnetical.

2. A ſtrong magnet has ſometimes communicated no higher magnetiſm than a weaker one; both have been able to ſaturate the bar.

3. A weak magnet has often impaired a ſtrong one by ſimply paſſing along it two or three times; but a piece of iron always improves a magnet by the ſame treatment.

Explanation. When the north pole of a weak but hard magnet is ſet on the north pole of a ſtrong one, it muſt certainly repel part of the fluid towards the other end, and thus it muſt weaken the magnet. When it is carried forward, it cannot repel this back again, becauſe it is not of itſelf ſuppoſed capable of making the magnet ſo ſtrong. But the end of a piece of iron, always acquiring a magnetiſm oppoſite to that of the part which it touches, muſt increaſe the accumulation of fluid where it is already condenſed, and muſt expel more from thoſe parts which are already deficient.

4. All the parts of the proceſs of the double touch, as practiſed by Meſſrs Mitchell and Canton, are eaſily explained by this hypotheſis. A particle of fluid p (fig. 33.), ſituated in the middle between the two magnets, is repelled in the direction $p\,e$ by the redundant pole of the magnet AN, whoſe centre of effort is ſuppoſed to be

ing at A. It is attracted with an equal force in the direction *p d* toward the centre of effort of the deficient pole of *N S*. By these combined actions it is impelled in the direction *p f*. Now it is plain that, although by increasing the distance between *N* and S, the forces with which these poles act on *p* are diminished, yet the compound force *p f* may increase by the diminution of the angle *d p e*. If the action is as $\frac{1}{x^2}$, *p f* will be greatest when $\frac{\text{Cof. } d p f}{d p^2}$ is a maximum, or (nearly) when Sin.^{2} $d p f \times$ Cof. $d p f$ is a maximum: but this depends on the place of the centre of effort. We can, however, gather from this observation, that the nearer we suppose the centres of effort of the poles N and S to the extremities of the magnets, the nearer must they be placed to each other. But we must also attend to another circumstance; that by bringing the poles nearer together, although we produce a greater action on the intervening fluid, this action is exerted on a smaller quantity of it, and therefore a less effect may be produced. This makes a wider position preferable; but we have too imperfect a knowledge of the circumstances to be able to determine this with accuracy. The unfavourable action on the fluid beyond the magnets must also be considered. Yet all this may be ascertained with precision in some very simple instances, and the determination might be of service, if we had not a better method, independent of all hypotheses or theory; namely, to place the magnets at the distance where they are *observed* to lift the heaviest bar of iron; then we are certain that their action is most favourable, all circumstances being combined.

We also see a sufficient reason for preferring the position of the magnets employed by Mr Antheaume (and before him by Mr Servington Savery), in his process for making artificial magnets. The form of the parallelogram *d p e f* is then much more favourable, the diagonal *p f* being much longer.

We also see, in general, that, by the method of double touch, a much greater accumulation of fluid may be produced than by any other known process.

And, lastly, since no appearances indicate any difference between natural and artificial magnetism, this hypothesis is equally applicable to the explanation of the phenomena of natural magnetism; such as the position of the horizontal, and of the dipping needle, and the impregnation of natural loadstones.

Having such a body of evidence for the aptitude of this hypothesis for the explanation of phenomena, it will surely be agreeable to meet with any circumstances which render the hypothesis itself more probable. These are not wanting: although it must be acknowledged that nothing has yet appeared, besides the phenomena of magnetism, to give us any indication of the existence of such a fluid; but there are many particulars in their appearance which greatly resemble the mechanical properties of a fluid.

81
Probability of the existence of magnetical fluid.

Heating a rod of iron, and allowing it to cool in a position perpendicular to the magnetic direction, destroys its magnetism. Iron is expanded by heat. If the particles of the magnetic fluid are retained between those of the iron, notwithstanding the forces which tend to diffuse them uniformly, they may thus escape from between the ferruginous particles which withheld them. For similar reasons, magnetism should be acquired by heating a bar and letting it cool in the magnetic direction. But, besides this evident mechanical *momentum* of motion, the union of fire (or whatever name the theologists may choose to give to the cause of expansion and of heat) with the particles of iron may totally change the action of those particles on the particles of fluid in immediate contact with them; nay, it may even change the sensible law of action between magnet and magnet. Of this no one can doubt who understands the application of mathematical science to corpuscular attraction (See Boscovich, *Suppl.*) A change may be produced in the action between magnets without any remarkable change happening in the actions within the magnet, and it may be just the reverse. The union of fire with the magnetic fluid may increase the mutual repulsion of its parts, as it does in all aerial fluids or gases. This alone would produce a dissipation of some magnetism. It may increase the attraction (at insensible distances) between the fluid and the iron, as it does in numberless cases in chemistry.

82
Farther grounds of belief.

It is well known that violently knocking or hammering a magnet weakens its force, and that hammering a piece of iron in the magnetic direction will give it some magnetism. By this treatment the parts of the iron are put into a tremulous motion, alternately approaching and receding from each other. In the instants of their recess, the pent-up particles of the fluid may make their escape. A quantity of small shot may be uniformly mixed with a quantity of wheat, and will remain so for ever, if nothing disturb the vessel; but continue to tap it smartly with a stick for a long time, and the grains of small shot will escape from their confinements, and will all go to the bottom. We may conceive the particles of magnetic fluid to be affected in the same way. The same effect is produced by grinding or filing magnets and loadstones. The latter are frequently made worthless by grinding them into the proper shape. This should be avoided as much as possible, and it should always be done in moulds made of soft iron and very massive; but this will not always prevent the dissipation of *strong* magnetism. As a farther reason for assigning this cause for the dissipation in such cases, it must be observed (Muschenbroek takes notice of it), that a magnet or loadstone may be ground at its neutral point without much damage. But we had the following most distinct example of the process. A very fine artificial magnet was suspended by a thread, with its south pole down. A person was employed to knock it incessantly with a piece of pebble, in such a manner as to make it ring very clearly, being extremely hard and elastic. Its magnetism was examined from time to time with a very small compass needle. In three quarters of an hour, its magnetism was not only destroyed, but the lower end shewed signs of a north pole. The same magnet was again touched, and made as strong as before, and was then wound about very tight with wetted whipcord, leaving a small part bare in the middle. It was again knocked with the pebble, but could no longer ring. At the end of three quarters of an hour its magnetism was still vigorous, and was not near gone after two hours and a quarter. We discharged a Leyden jar (coated with gold leaf) in the same way. It stood on the top of an axis; and while this was turned round, the edge was rubbed with a very dry cork filled with

with rosin, and soldered to the end of a glass rod. This made the piece sound like the glass of a harmonica. One of them was split in this operation.

A small bar of steel was heated red hot and tempered between two strong magnets lying in the low box filled with water, and was more strongly impregnated in this way than in any other that we could think of for a bar of that shape. It has not yet been ascertained in what temperature it is most susceptible of magnetism, but it was considerably hotter than to be just visible in a dark place. It is no objection to our way of conceiving magnetism, that the fluid is immoveable or inactive when the iron is red hot. Either of these, or both of them, may result from the union with the cause of heat. Even a particular degree of expansion may so change the law of action as to make it *immoveable*; or the union with caloric may render it *inactive* at all sensible distances. We cannot but think, that some very instructive facts might be obtained by experiments made on iron in the moment of its production, and changes in various chemical processes. All magnetism is gone when it is united with sulphur and arsenic in the greatest number of ores; and when it is in the state of an ochre, rust, æthiops, or solution in acids; and when united with astringent substances, such as galls. When, and in what state, does it become magnetic? And whence comes the fluid of Æpinus? It were worth while to try, whether magnets have any influence in the formation or crystallization of the martial salts; and what will be their effect on iron when precipitated from its solutions by another metal, &c. &c.

83 Why magnets have always more than one pole.

There remains one remarkable fact to be taken notice of, which, in one point of view, is a confirmation of the hypothesis, but in another presents considerable difficulties. It is well known, that no magnet has ever been seen which has but one pole; that is, on the hypothesis of Æpinus, which is wholly redundant, or wholly deficient. If all magnetism be either the immediate or the remote effect of the great magnet contained in the earth, and if it be produced by induction, without any communication of substance, but only by changing the disposition of the fluid already in the iron, we never should see a magnet with only one pole. It must be owned, that we never can make such a magnet by any of the processes hitherto described; but the existence of such does not seem impossible. Supposing a magnet, of the most regular magnetism, having only two poles; and that we cut it through at the neutral point, or that we cut or break off any part of it—the fact is, (for the experiment has been tried ever since men began to speculate about magnetism), that each part becomes an ordinary magnet, with two poles, one of which is of the same kind as before the separation. The question now is, What should happen according to the theory maintained by Æpinus?—*Tentam. Theor. Electr. et Magnetismi*, p. 104, &c.

Let NAS (fig. 24.) be a magnet, of which N is the overcharged pole. Let the ordinates of the curve DAE express the difference between the natural density of the fluid, in a state of uniform diffusion, and its density as it is really disposed in the magnet. The area pn ND will there express the quantity of redundant fluid in the part nN, and the area qESm express the fluid wanting in the part Sm. The intersection A marks that part of the magnet where the fluid is of its natural density. Suppose the part Nn to be separated from the rest, containing the redundant fluid NDpn. The tendency of this fluid to escape from the iron with which it is connected will be greater (Mr Æpinus thinks) than before, because its tendency to quit the magnet formerly was opposed by the attractions of the redundant matter contained in AS. This is certainly true of the extremity N; and, perhaps of all the old external surface. Fluid will therefore escape. Suppose that so much has quitted the iron that the point n has the fluid of its natural density, as is represented in n° 3. there is still a force operating at n, tending to escape, arising from the repulsion of all the redundant fluid nDN. If this be sufficient for overcoming the obstruction, it will really escape, and the iron will be left in the state represented by n° 4. with an overcharged part fN, and an undercharged part fn.

In like manner, the tendency of the magnetic fluid surrounding the magnet to enter into its deficient pole, will be greater when it is separated from the other, not being checked by the repulsion of the redundant fluid in that other

Mr Æpinus relates some experiments which he made on this subject. The general result of them was, that the moment the parts were separated, each had two poles, and that the neutral point of each fragment was much nearer to the place of their former union than to their other ends. In a quarter of an hour afterward, the neutral points had advanced nearer to their middles, and continued to do so, by very small steps, for some hours, and sometimes days, and finally were stationary in their middles.

We acknowledge, that this reasoning does not altogether satisfy us, and that the gradual progress of the neutral point toward the middle of each piece, although agreeable to what should result from an escape of fluid, is not a proof of it. We knew already, that the production of magnetism is a progressive thing; and we should have expected this change of the situation of the neutral point, whatever be the nature of magnetism. There is something similar to this, and perhaps equally puzzling, in the immediate recovery of magnetism which has been weakened by heat, it is partly recovered on cooling.

But our chief difficulty is this: At the point A (fig. 34.) every thing is in equilibrium before the fracture. The particle A is repelled by the redundant fluid in AN, and attracted by the redundant matter in AS; yet it does not move, for the magnetism is supposed to have permanency. Therefore the obstruction at A cannot be overcome by the united repulsion of AN and attraction of AS. Nor can the obstruction at N be overcome by the difference of these two forces. Now suppose AS annihilated. The change made on the state of things at A is surely greater than that at N, because the force abstracted is greater, the distance being less. It does not clearly appear, therefore, that the removal of AS should occasion an efflux at N. This, however, is not impossible; because the fluid may be so disposed, by great constipation near N, and no great excess of density near A, that a smaller change at N may produce an efflux there. But surely the tendency to escape at A must now be diminished, instead of being greater after the fracture. And if any escape from N, this will still more diminish that tendency to escape

from

from A. It does not therefore appear a clear consequence of the general theory, that the constipated fluid should escape; and more particularly, that A should become deficient. And with respect to the entry of fluid into the other fragment, and its becoming overcharged at *m*, the reasoning seems still less convincing. The steps of the physical process in the two parts of the original magnet are by no means convertible or counterparts of each other. There is nothing in the part AS to resemble the force of repulsion really exerting itself in the corresponding point of AN. There would be, if there were a particle of fluid in that place; but there is not. The tendency therefore of external fluid to enter there, does not resemble the tendency of the internal fluid to expand and dissipate. It is true, indeed, the discourse should be confined to points of the surface. But the internal motion must also be considered; and the great objection always remains, namely, that the obstruction at A (n° 1.) or at *n* (n° 3.) is sufficient to prevent the passage of a particle of fluid from the pole AN into the pole AS, when urged by the repulsion of the fluid in the one and the attraction of the iron in the other; and yet will not prevent the escape of a particle when one of those causes of motion is removed. Add to this, that the whole hypothesis assumes as a principle, that the resistance to escape from any point is greater than the obstruction to motion through the pores. This is readily granted; for however great we suppose the attraction, in the limits of physical contact, it will be no obstruction to motion through the pores, because the particle is equally affected by the opposite sides of the pores; whereas, in quitting the body altogether, there is nothing beyond the body to counteract the attraction by which it is retained.

There seems something wanting to accommodate this beautiful hypothesis of Mr Æpinus to this remarkable phenomenon; and the coincidence is otherwise so complete, that we are almost obliged to conclude that it is merely a deficiency, arising from our not having a sufficient knowledge of the law of magnetic action. This is quite sufficient: For it may be strictly demonstrated, that if the magnetic action decreases in higher ratio than that of the squares of the distances, the permanency of the fluid in any particular disposition has scarcely any dependence on the particles at any sensible distance, and is affected only by the *variations* of its density (See Electricity, *Suppl.* n° 217. for a case somewhat similar). Therefore, if the fluid be so disposed, that its density may be represented by the ordinates of such a curve as is drawn in fig. 34. having its two extremities concave toward the axis, and a point of contrary flexure at A, the tendency to escape at A will be the greatest possible; and when the magnet is broken at A (n° 1.), or when the fluid has taken the arrangement represented by n° 3. it *cannot* stop there, and *must* become deficient in that part. Now, it must be acknowledged, that we are not absolutely certain that the magnetic action is in the precise inverse duplicate ratio of the distance. All that we are certain of is, that it is much nearer to it than to either the inverse simple or inverse triplicate ratio. We own ourselves rather disposed to ascribe the present difficulty to our ignorance of some circumstance, purely mathematical, overlooked, or mistaken, than to think a conjecture unfounded, which tallies so accurately with such a variety of phenomena.

We may here observe, that we are not altogether satisfied with Æpinus's form of the experiment. He did not break a magnet; he set two steel bars end to end, and touched them as one bar, making the magnetism perfectly regular; he then separated them, and found that each had two poles. But was he certain that, when joined, they made but one magnet? We have sometimes succeeded in doing this, as we thought, by the curves of iron filings; but on putting the needle with which we were examining their polarity into proper situations, we sometimes found it in the second intersection of the secondary curves, shewing that the bars were really two magnets, and not one.

On the other hand, when a piece is broken off from a magnet, the succussion and elastic tremor into which the parts are thrown, and even the bending previous to the fracture, may give opportunity to a dissipation, which could not otherwise happen. The parts should be separated by corrosion in an acid, and the gradual change of magnetism should be carefully noted. The writer of this article has made some experiments of this nature, the results of which present some curious observations; but they are not yet brought to a conclusion that is fit to be laid before the public.

85 Hypothesis of Prevôt.

Mr Prevôt of Geneva, in a dissertation on the origin of magnetic forces, endeavours to give a theory which obviates the only difficulty in that of Æpinus; but it is incomparably more complex, employing two fluids, which by their union compose a third, which he calls combined fluid. There is much ingenuity, and even mathematical address, in adjusting the relative properties of those fluids. But some of them are palpably incompatible; *ex. gr.* the particles of each attract each other, but those of the other kind most strongly; yet they are both elastic like air. This is surely inconceivable.—Granting this, however, he suits his different attractions, so that a strong elective attraction of the combined fluid for iron decomposes part of the fluid in the iron, and each of its ingredients occupies opposite ends of the bar: then will the bars approach or recede, according as the near ends contain a different or the same ingredient. All this is operated without repulsion.

But the whole of this is mere accommodation, like Æpinus's, but so much more complex, that it requires very intense contemplation to follow the author through the consequences. Add to this, that his attractions are operated by another fluid, infinitely more subtle than either of those already mentioned, every particle of these being, as it were, a world in comparison of those of the other. In short, he adopts all the extravagant suppositions of Le Sage of Geneva, and every thing is ultimately impulsion. Nor is the contrivance for obviating the difficulty (so often mentioned) at all clear and convincing; and it is equally gratuitous with the rest. We cannot think this hypothesis at all intitled to the name of *explanation*.

86 Remarks on hypotheses.

This must serve for an account of the hypothesis of Æpinus. The philosophical reader will see, that however exactly it may tally with every phenomenon, it cannot be called an explanation of the phenomena; because it is the phenomena which explain the hypothesis, or give us the characters of the magnetic fluid, if such

such fluid exists But we are not obliged to admit this existence, as we admit that to be the true decyphering of a letter which makes sense of it. In that case we know both parts of the subject—the characters and the sounds; but are ignorant which corresponds to which. Did we see a fluid abstracted from one part of a bar and constipated in another, and perceive the abstraction and constipation always accompanied by the observed attractions and repulsions, the rules of philosophical discussion, nay, the constitution of our own mind, would oblige us to assign the one as the cause or occasion of the other. But this important circumstance is wanting in the present case. We think, however, that it merits a close attention; and we entertain great hopes of its being one day completed, by including this single exception.

At the same time, it must be owned, that it gives no extension of knowledge; for it can have no greater extension than the phenomena on which it is founded, and cannot, without risk of error, be applied to an untried case, of a kind dissimilar in its nature to the phenomena on which it is founded. We doubt not but that its ingenious author would have said, that a bit broken off from the north pole of a magnet would be wholly a north pole, if he had not known that the fact was otherwise.

But this hypothesis greatly aids the imagination in conceiving the process of the magnetical phenomena. The more we study them, the more do they appear to resemble the protrusion of a fluid through the parts of an obstructing body. It proceeds gradually. It may be, as it were, overdone, and regorges when the propelling cause is removed. The motion is aided by what we know to aid other obstructed motions. As a fluid would be constipated in all protuberances, so the faculty of producing the phenomena is greater in all such situations, &c. &c. This, joined to the impossibility of speaking, with clearness of conception, of the propagation of powers without the protrusion of something in which they inhere, gives it a hold of the imagination which is not easily shaken off.

To say that nothing is explained when the attraction of the fluid is not explained, and that this is the main question, gives us little concern. We offer no explanation of this attraction, more than of the attraction of gravity. There is nothing contrary to the laws of human intellect, nothing inconsistent with the rules of reasoning, in saying, that things are so constituted, that when two particles are together, they separate, although we are ignorant of the immediate cause of their separation. Those who think that all motion is performed by impulsion, and who explain magnetism by a stream of fluid circulating round the magnet, must have another fluid to impel this fluid into its curvilineal path; for they insist, that the planets are so impelled. Then they must have a third fluid to deflect the vertical motions of the second, and so on without end. This is evident, and it is absurd. But we have said enough in the article IMPULSION, *Suppl.* to shew that all *hypotheses* framed on purpose to explain action *e distanti* by impulsion are illogical; because impulsion requires explanation as much as the other, and neither the one nor the other will ever be resolved into any thing but the FIAT of the Allwise Author of the universe.

We conclude with desiring the reader to remark, that the explanation which we have given of the magnetical phenomena is independent of the hypothesis of Æpinus, or any hypothesis whatever. We have narrated a variety of very distinguishable facts, and have marked their distinctions. We have been able to reduce them to general classes; and even to groupe those classes into others still more general; and at last, to point out one which is discoverable in them all. This is giving a philosophical theory, in the strictest sense of the word; because we shew, in every case, the modification of the general fact which allots it this or that particular place in the classification. Thus we have shewn that the polarity or directive power of magnets is only a modification of the general fact of attraction and repulsion. Dr Gilbert's theory of *terrestrial* magnetism is indeed a hypothesis, and we enounced it as such. It only claims probability, and we apprehend that a very high degree of credit will be given to it. 87 The preceding theory is not a hypothesis.

We hope that many of our readers will have their curiosity excited by the account we have given of Æpinus's theory. To such we earnestly recommend the serious perusal of his book *Tentamen Theoriæ Electricitatis et Magnetismi, Auct. F. Æpino, Petropoli*, 1759 Van Swinden has included a very good abstract of it in his 2d volume *Sur l'Electricité*, written by Professor Steiglehner of Ratisbon or Ingolstadt. The mathematical part is greatly simplified, and the whole is presented in a very clear and accurate manner. Mr Van Swinden is a professed foe to all hypotheses; but he is not moderate, and we wish that we could say that he is candid. He attacks every thing; and takes the opportunity of every analogy pointed out by Æpinus between magnetism and electricity to repeat the first sentence of his dissertation, namely, that magnetism and electricity are not the same; a thing that Æpinus also maintains. But he even charges Æpinus with a mistake in his fundamental equations, which invalidates his whole theory. He says that Æpinus has omitted one of the acting forces assumed in his hypothesis. This is a most groundless charge; and we own that we cannot conceive how Van Swinden could fall into such a mistake. We are unwilling to call it intentional, for the mere purpose of raising a man of straw to knock him down again. Abbé Haüy of the French Academy has also published an abridgment of Æpinus's theory, with many excellent remarks, tending to clear the theory of the only defect that has been found in it. This work was much approved of, and recommended by the Academy. We have not had the good fortune to see a copy of it.

88 Analogy of magnetism to electricity.

The reader cannot but have remarked the close analogy between the magnetical phenomena and those of induced electricity; indeed, all the phenomena of attraction and repulsion are the same in both. The mechanical composition of those actions produces a directive power and a polarity, in electrical as well as in magnetical bodies. We can make an electrical needle which will arrange itself, with respect to the overcharged and undercharged ends of a body electrified by mere position, just as a compass needle is arranged by a magnet. We can touch a stick of sealing wax in the manner of the double touch, so as to give it poles of considerable force and durability. As a red hot steel bar acquires permanent poles by quenching it near a magnet, so melted wax acquires them by freezing in the neighbourhood of a positive

poſitive and negative electric. Some have inferred a ſameneſs of origin of theſe two ſpecies of powers from theſe various circumſtances of reſemblance: but the original cauſes ſeem to be diſtinct on many accounts. Electricity is common to all bodies. The cauſe of magnetiſm can operate only on iron. Although lightning or an electrical ſhock gives polarity to a needle, we need not infer the identity of the cauſe becauſe the polarity which it gives is always the ſame with that given by great heat; and there is always intenſe heat in this operation. The phenomenon which looks the moſt like an indication of identity of the origin of electricity and magnetiſm is the direction of the rays of the aurora borealis—they converge to the ſame point of the heavens to which the elevated pole of the dipping needle directs itſelf. But this is by no means a ſufficient foundation for eſtabliſhing a ſameneſs. Electricity and magnetiſm may, however, be related by means of ſome powers hitherto unknown. But we are decidedly of opinion, that the electric and magnetic fluids are totally different, although their mechanical actions are ſo like that there is hardly a phenomenon in the one which has not an exact counterpart in the other. But we ſee them both operating, with all their marks of diſtinction, in the ſame body; for iron and loadſtones may be electrified, like any other body, and their magnetiſm ſuffers no change or modification. We can ſet theſe two forces in oppoſition or compoſition, juſt as we can oppoſe or compound gravity with either. While the iron filings are arranging themſelves round a magnet, the mechanical action of electricity may be employed either to promote or hinder the arrangement. They are therefore diſtinct powers, inherent in different ſubjects.

But there are abundance of other phenomena which ſhew this diverſity. There is nothing in magnetiſm like a body overcharged or undercharged *in toto*. There is nothing which indicates the preſence of the fluid to the other ſenſes—nothing like the ſpark, the ſnap, the viſible diſſipation; becauſe the magnetic fluid enters into no union with air, or any thing but iron. There is nothing reſembling that inconceivably rapid motion which we ſee in electricity; the quickeſt motion of magnetiſm ſeems inferior (even beyond compariſon) with the ſloweſt motion along any electric conductor. Therefore there is no poſſibility of diſcharging a magnet as we diſcharge a coated plate. Indeed, the reſemblance between a magnet and a coated plate of glaſs is exceedingly ſlight. The only reſemblance is between the magnet and an inconceivably thin ſtratum of the glaſs, which ſtratum is poſitive in one ſide and negative in the other. The only perfect reſemblance is between the induced magnetiſm of common iron, and the induced electricity of a conductor.

[illegible]

The following ſeem the moſt inſtructive diſſertations on magnetiſm, either as valuable collections of obſervations, or as judicious reaſonings from them, or as the ſpeculations of eminent or ingenious men concerning the nature of magnetiſm.

Gilbertus de Magnete, Lond. 1600, fol.

Æpini Tentamen Theoriæ Magn. et Electr.

Eberhard's Tentam. Theor. Magnetiſmi, 1720.

Diſſertations ſur l'aimant, par du Fay, 1728.

Muſchenbroek Diſſert. Phyſico Experimentalis de Magnete.

Pieces qui ont emporté le prix de l'Acad. des Sciences: Paris ſur la meilleure conſtruction des Bouſſoles de declination. Recueil des pieces couron. , tom

Euleri opuſcula, tom iii continens Theor. Magnetis, Berlin, 1751.

Æpini Oratio Academica, 1758.

Æpini item Comment. Petrop. nov. tom x.

Anton. Brugmanni tentam. Phil. de materia Magnetica, Franequeræ. 1765.

There is a German tranſlation of this work by Eiſenbach, with many very valuable additions.

Scarella de Magnete, 2 tom fol.

Van Swinden Tentamina Magnetica, 4to.

Van Swinden ſur l'Analogie entre les phenomenes Electriques et Magnetiques, 3 Tom. 8vo.

Diſſertation ſur les Aimans artificielles par Antheaume.

Experiences ſur les Aimans artificielles par Nicholas, Fuſs, 1782.

Eſſai ſur l'Origine des Forces Magnetiques par Mr Prevoſt.

Sur les Aimans artificielles par Rivoir, Paris 1752.

Diſſertatio de Magnetiſmo par Sam. Klingenſtier et Jo. Brander, Holm. 1752.

Deſcription des Courants Magnetiques, Straſbourg, 1753.

Traité de l'Aiman par Dalancé, Amſt. 1687.

Beſides theſe original works, we have ſeveral diſſertations on magnetical vortices by Des Cartes, Bernoulli, Euler, Du Tour, &c. publiſhed in the collections of the works of thoſe authors, and many diſſertations in the memoirs of different academies; and there are many popular treatiſes by the traders in experimental philoſophy in London and Paris. Dr Gown Knight, the perſon in Europe who was moſt eminently ſkilled in the knowledge of the phenomena, alſo publiſhed a diſſertation intitled, *An attempt to explain the Phenomena of Nature by two principles, Attraction and Repulſion*, Lond. 1748, 4to, in which he has included a theory of magnetiſm. It is a very curious work, and ſhould be ſtudied by all thoſe who have recourſe without ſcruple to the agency of inviſible fluids, when they are tired of patient thinking. They would there ſee what thought and combination are neceſſary before an inviſible fluid can be really fitted for performing any office we chooſe to aſſign it. And they will get real inſtruction as to what ſervices we may expect of ſuch agents, and from what taſks they muſt be excluded. The Doctor's theory of magnetiſm is very unlike the reſt of the performance; for he does not avail himſelf of the vaſt apparatus of propoſitions which he had eſtabliſhed, and adopts without any nice adjuſtment the moſt common notions of an impulſive vortex. Both the production and maintenance of this vortex, and its mode of operation, are irreconcileable with the acknowledged laws of impulſion.

Si quid noviſti rectius iſtis, candidus imperti—ſi non his utere mecum.

APPENDIX.

Investigation of the magnetic curve.

We have been favoured with the following inveſtigation of the curves, to which a needle of indefinite minuteneſs will be a tangent, by Mr Playfair, Profeſſor of Mathematics in the Univerſity of Edinburgh.

Two magnetical poles being given in pofition, the force of each of which is fuppofed to be as the mth power of the diftance from it reciprocally, it is required to find a curve, in any point of which a needle (indefinitely fhort) being placed, its direction, when at reft, may be a tangent to the curve?

1. Let A and B (fig. 35.) be the poles of a magnet, C any point in the curve required; then we may fuppofe the one of thefe poles to act on the needle only by repulfion, and the other only by attraction, and the direction of the needle, when at reft, will be the diagonal of a parallelogram, the fides of which reprefent thefe forces. Therefore, having joined AC and BC, let AD be drawn parallel to BC, and make $\frac{1}{AC^m} : \frac{1}{BC^m} :: AC : AD$; join CD, then CDF will touch the curve in C.

2. Hence an expreffion for AF may be obtained. For, by the conftruction, $AD = \frac{AC^{m+1}}{BC^m}$, and fince $BC : AD :: BF : FA$, and $BC - AD : AD :: AB : AF$, we have $AF = \frac{AB \times AC^{m+1}}{BC^{m+1} - AC^{m+1}}$.

3. A fluxionary expreffion for AF may alfo be found in terms of the angles CAB, ABC. In CF take the indefinitely fmall part CH, draw AH, BH, and from C draw CL perpendicular to AH and CK to BH. Draw alfo BC and AM at right angles to FH. Let the angles $CAB = \phi$, and $CBA = \psi$; then $CAH = \dot{\phi}$, and $CBH = -\dot{\psi}$; alfo $CL = AC \times \dot{\phi}$, and $CK = -BC \times \dot{\psi}$. Now $HC : CL :: AC : AM = \frac{AC^2 \times \dot{\phi}}{HC}$; and for the fame reafon $BC = -\frac{BC^2 \times \dot{\psi}}{HC}$. Therefore fince $AF : FB :: AM : BC$, $AF : FB :: \frac{AC^2 \times \dot{\phi}}{HC} : -\frac{BC^2 \times \dot{\psi}}{HC}$, and $AF : AB :: \text{fin.}\,\psi^2\,\dot{\phi} : -\text{fin.}\,\psi^2\,\dot{\phi} - \text{fin.}\,\phi^2\,\dot{\psi}$; wherefore if $AB = a$, $AF = \frac{-a\,\dot{\phi}\,\text{fin.}\,\psi^2}{\dot{\psi}\,\text{fin.}\,\phi^2 + \dot{\phi}\,\text{fin.}\,\psi^2}$.

4. If this value of AF be put equal to that already found, a fluxionary equation will be obtained, by the integration of which the curve may be constructed. Becaufe $AF = \frac{AB \times AC^{m+1}}{BC^{m+1} - AC^{m+1}}$; and fince $AC = \frac{a\,\text{fin.}\,\psi}{\text{fin.}\,(\phi + \psi)}$, and $BC = \frac{a\,\text{fin.}\,\phi}{\text{fin.}\,(\phi + \psi)}$, we have by fubftitution $AF = \frac{a\,\text{fin.}\,\psi^{m+1}}{\text{fin.}\,\phi^{m+1} - \text{fin.}\,\psi^{m+1}} = -\frac{a\,\dot{\phi}\,\text{fin.}\,\psi^2}{\dot{\psi}\,\text{fin.}\,\phi^2 + \dot{\phi}\,\text{fin.}\,\psi^2}$. Hence, $\text{fin.}\,\phi^2 \times \dot{\psi}\,\text{fin.}\,\psi^{m+1} + \dot{\phi}\,\text{fin.}\,\psi^{m+3} = -\text{fin.}\,\psi^2 \times \dot{\phi}\,\text{fin.}\,\phi^{m+1} + \dot{\phi}\,\text{fin.}\,\psi^{m+3}$, and therefore $\dot{\psi}\,\text{fin.}\,\psi^{m-1} = -\dot{\phi}\,\text{fin.}\,\phi^{m-1}$; and alfo, $\int \dot{\psi}\,\text{fin.}\,\psi^{m-1} + \int \dot{\phi}\,\text{fin.}\,\phi^{m-1} = C$.

5. Thefe fluents are eafily found when m is any whole pofitive number.

If $m = 1$, we have $\dot{\psi} + \dot{\phi} = 0$.
$m = 2$, $\dot{\psi}\,\text{fin.}\,\psi + \dot{\phi}\,\text{fin.}\,\phi = 0$.
$m = 3$, $\dot{\psi}\,\text{fin.}\,\psi^2 + \dot{\phi}\,\text{fin.}\,\phi^2 = 0$.
$m = 4$, $\dot{\psi}\,\text{fin.}\,\psi^3 + \dot{\phi}\,\text{fin.}\,\phi^3 = 0$, &c.
Therefore, &c.
Alfo if $m = 1$, $\phi + \psi = C$.
$m = 2$, $\text{cof.}\,\phi + \text{cof.}\,\psi = C$.
$m = 3$, $-\text{fin.}\,2\phi + 2\phi - \text{fin}\,2\psi + 2\psi = C$.
$m = 4$, $\text{cof}\,3\phi - 9\,\text{cof.}\,\phi + \text{cof}\,3\psi - 9\,\text{cof.}\,\psi = C$, &c. &c.

The firft of the above equations belongs to a fegment of a circle defcribed upon AB, which therefore would be the curve required if the magnetical force were inverfely as the diftances.

If the magnetical force be inverfely as the fquare of the diftance, that is, if $m = 2$, $\text{cof.}\,\phi + \text{cof.}\,\psi$ is equal to a conftant quantity. Hence if, befide the points A and B, any other point be given in the curve, the whole may be defcribed. For inftance, let the point E (fig. 36.) be given in the curve, and in the line DE which bifects AB at right angles. Defcribe from the centre A a circle through E, viz. QER; then AD being the cofine of DAE to the radius AE, the fum of the cofines of $\phi \times \psi$ will be everywhere (to the fame radius) = 2 AD = AB. Therefore to find E, the point in which any other line AN, making a given angle with AB, meets the curve, draw from N, the point in which it meets the circumference of the circle QER, NO, perpendicular to AB, fo that AO may be the cofine of NAO, and from O toward A take OP = AB, then AP will be the cofine of the angle ABE; fo to find BE′, draw PQ perpendicular to AP, meeting the circle in Q; join AQ, and draw BE′ parallel to AQ, meeting AE′ in E′, the point E′ is in the curve. In this way the other points of the curve may be found.

The curve will pafs through B, and will cut AB at an angle of which the cofine = RB. If then E be fuch, that AE = AB, the curve will cut AB at right angles. If E″ be more remote from A, the curve will make with AB an obtufe angle toward D; in other cafes it will make with it an acute angle.

A conftruction fomewhat more expeditious may be had by defcribing the femicircle AFB, cutting AE in F, and AE′ in N, and defcribing a circle round A, with the diftance AL = 2AF, cutting AE in L. If AG be applied in the femicircle AFB = NL, AG muft cut AN in a point E of the curve, becaufe AN + BG = 2 AF, and AN and GB are cofines of the angles at A and B.

As the lines AN and BG may be applied either above or below AB, there is another fituation of their interfection E′. Thus A n being applied above, and B g below, the interfection is in e. The curve has a branch extending below A; and if D e be made = DF, and B e be drawn, it will be an affymptote to this branch. There is a fimilar branch below B. But thefe portions of the curve evidently fuppofe an oppofite direction of one of the two magnetic forces, and therefore have no connection with the pofition of the needle.

We omitted the inferting in its proper place, n° 65. Add.
a hypothefis of the celebrated aftronomer Tobias Mayer, n° 6
of Gottingen, by which the direction of the mariner's needle in all parts of the earth may be determined. He fuppofes that the earth contains a very powerful magnet of inconfiderable dimenfions, which arranges the needle according to the known laws of magnetifm. The centre of this magnet was diftant from the centre of the earth about 480 Englifh miles in 1756, and a line joining thefe centres interfected the earth's furface in a point fituated in 17° N. Lat. and 183° E. Long. from London. The axis of the magnet is perpendicular to this line, and the plane in which it lies is inclined about 11° to the plane of the meridian, the north end of the axis lying on the eaft fide of that meridian.

 From

From these data, it will be found that the axis of this magnet cuts the surface of the earth about the middle of the eastern shore of Baffin's Bay, and in another point about 800 miles S.S.W. of the southern point of New Zealand. Professor Lichtenberg of Gottingen, who gives this extract from the manuscript, says, that the hypothesis is accompanied by a considerable list of variations and dips calculated by it, and compared with observations, and that the agreement is very remarkable. He gives indeed a dozen instances in very different regions of the earth. But we suspect that there is some error or defect in the data given by him, because the annual changes, which he also gives, are such as are inconsistent with the data, and even with each other. He says, that the distance from the centre increases about four miles annually, and that *thence* arises an annual diminution of 8 minutes in the latitude and 14 in the longitude of that point where the straight line joining the centres meets the surface. It can have no such consequence. He says also, that the above mentioned inclination of the planes increases 8 minutes annually. The compound force of the magnet is said to be as the square root of the distance inversely. We are at a loss to understand the meaning of this circumstance; because Mayer's hypothesis concerning the law of magnetic action is exceedingly different, as related by Mr Lichtenberg from the same manuscript. But it was our duty to communicate this notice, though imperfect, of the speculations of this celebrated mathematician. See *Erxleben's Elem. of Nat. Phil.* published by Lichtenberg 1784, p. 645.

Addition to n° 64.

Addition to n° 64. Let HZOF (fig. 37.) be the plane of a magnetic meridian, H n' O the plane of the horizon, and NS the position of the magnetic needle in any place, when it is at liberty to settle in the true magnetic direction. The angle HON is the inclination or dip of the needle. Let Z n F be a vertical circle, in which a well constructed dipping needle can freely play up and down. This needle cannot place itself in the magnetic direction, because it can only move in a vertical plane. Its north point is impelled in the direction $n\,o$, and its south point in the direction $s\,p$, both of which are parallel to NS. By the laws of mechanical equilibrium, it cannot rest, except in such a position that the forces $n\,o$ and $s\,p$ are in a plane perpendicular to the plane Z n F. In any other position, there would be a force impelling the needle toward that side on which $n\,o$ makes an acute angle with the tangent $r\,n\,t$ of the vertical circle. Therefore the spherical triangle N n F is right angled in n, and Cos. NFn : R = Tan. n F : Tan. NF, = Tan. HN : Tan. n' n. Therefore

$$\text{Tan. } n'n = \frac{\text{Tan. HN}}{\text{Cos. H}n'}, = \text{Tan. HN} \times \text{Sec. H}n'.$$

Therefore, in any place, the real inclination of the magnetical direction to the horizon is different from what is pointed out by a dipping needle when it is in a plane which declines from the magnetic meridian; and the tangent of the observed dip of the needle exceeds that of the inclination of the magnetic direction in the proportion of radius to the cosine of the deviation HCn', or the proportion of the secant of this angle to the radius. If therefore the dipping needle play in a magnetic east and west circle, it will stand perpendicular to the horizon.

MAL

Malesherbes. MALESHERBES (Christian William de Lamoignon) was born December the 6th 1721. At the age of 24 he became a counsellor of Parliament, and six years afterwards chief president of the *cour des aides.* He remained in that important situation during a period of 25 years, and displayed on many occasions proofs of firmness, eloquence, and wisdom.

When the prince of Condé was sent by the king in 1768 to silence the magistrates who opposed the taxes, Malesherbes replied to him, "Truth, Sir, must indeed be formidable, since so many efforts are made to prevent its approach to the throne." About the same time that he became president of the *cour des aides*, he was appointed by his father, then chancellor of France, superintendant of the press; an office of the greatest importance, of which the principles which Malesherbes had imbibed from D'Alembert rendered him very ill qualified to discharge the duties. He was what the French called a *philosopher*; a term with them of the same import with a naturalist, who openly denies revealed religion, and has no adequate notions of the moral attributes of God. The consequence was, that when the authors of impious and immoral books were brought before him in his official capacity to undergo examination, he appeared to them as advising, assisting, and protecting them, against that very power which was vested in himself; and they were commonly dismissed with this senseless observation, that all books of whatever tendency should be considered merely as *objects of commerce.* Had it not been for the protecting influence of Malesherbes, the *Encyclopédie*, of which the publication was frequently suspended (see DIDEROT in this *Supplement*), would probably have been altogether suppressed; and the works of Rousseau and Raynal, which so powerfully contributed to that revolution in which he was overwhelmed, would certainly not have spread so rapidly over the kingdom of France. It was he, said D'Alembert, who *broke the shackles of literature.*

In vain will it be replied, that he left the same liberty to the religious as to the impious writers; for that was not always strictly true. The Abbé Barruel has brought the testimony of D'Alembert himself to prove, that it was much against his will that Malesherbes suffered works refuting the sophisters to appear; and, as he very properly observes, what a minister allows with reluctance, he finds abundant means of preventing.

In 1775 he resigned the office of chief president of the *cour des aides*, and was appointed minister and secretary of state in the place of La Vrillière. Thus placed in the centre of a frivolous yet brilliant court, Malesherbes did not in the least deviate from his former simplicity of life and manners; but, in lieu of complying with the established etiquette which required magistrates, when they became ministers of state, to exchange their sable habit and head dress for a coloured suit, bag-wig, and sword, he retained his black coat and magisterial *peruke!* This is recorded by a panegyrist to his honour; but we perceive not the honour which

which it reflects on him. It surely requires no great powers of abstraction to discover, that a coloured coat, bag-wig, and sword, are not in themselves more frivolous or contrary to nature, than a black coat and enormous peruke; and if the manners of a country have appropriated these different dresses to different stations in life, the individual must be actuated by a very absurd kind of pride, who sets up his own caprice against the public opinion.

As, when invested with the power to restrain within just limits the freedom of the press, it was his chief aim to encourage and extend that freedom; so, when raised to an office which gave him the unlimited power of issuing *lettres de cachet*, it was their total suppression that became the earliest object of his *most ardent* zeal. Till that time *lettres de cachet*, being considered as a part of the general police, as well as of the royal prerogative, were issued not only at the will of the minister, but even at the pleasure of a common clerk, or persons still more insignificant. Malesherbes began by relinquishing himself this absurd and iniquitous privilege. He delegated the right to a kind of tribunal, composed of the most upright magistrates, whose opinion was to be unanimous, and founded upon open and well established facts. He had but one more object to attain, and that was to substitute a legal tribunal in the place of that which he had established; and this object he was upon the point of accomplishing, when the intrigues of the court procured the dismission of Turgot; and Malesherbes, in consequence, resigned on the 12th of May 1776. For this part of his conduct he is intitled to praise, which we feel not ourselves inclined to withhold from his memory. Even M. Barruel admits, that he had many moral virtues, and that he displayed real benevolence when alleviating the rigours of imprisonment, and remedying the abuse of *lettres de cachet*; but France, says he, shall nevertheless demand of him her temples that have been destroyed; for it was he who, above all other ministers, abused his authority to establish in that kingdom the reign of impiety.

After this epoch he undertook several journeys into different parts of France, Holland, and Switzerland, where he collected with zeal and taste objects of every kind interesting to arts and sciences. As he travelled with the simplicity and economy of a man of letters, who had emerged from obscurity for the purpose of making observations and acquiring knowledge, he by that means was enabled to reserve his fortune for important occasions, in which it might procure him information on interesting subjects. He travelled slowly, and frequently on foot, that his observations might be the more minute; and employed part of his time in suitably arranging them. These observations formed a valuable collection of interesting matter relative to the arts and sciences, but which has been almost totally destroyed by the fury of revolutionists, who have done as much prejudice to the interests of science as of humanity.

Returning from his travels, Malesherbes for several years enjoyed a philosophic leisure, which he well knew how to direct to useful and important objects. The two treatises which he composed in the years 1785 and 1786 on the civil state of the protestants in France are well known. The law which he proposed in these, was only preparatory to a more extensive reform; and these treatises were to have been followed up by another work, the plan of which he had already laid down, when affairs growing too difficult to be managed by those who held the reins of government, they were compelled to call him to their councils. They did not, however, assign him the direction of any department, and introduced him merely (as subsequent events have shewn) to cover their transactions under a popular name, and pass them on the world as acts in which he had taken part. Malesherbes accepted their overtures merely to satisfy the desire he felt to reveal some useful truths; but it was not for that purpose that they had invited him to their councils. Those who presided at them took umbrage at his first efforts to call their attention to the voice of truth and wisdom; and succeeded so well in their opposition, that he was reduced to the necessity of delivering in writing the counsel which he wished to offer. Such was the origin of two treatises relative to the calamities of France, and the means of repairing them. He transmitted these treatises to the king, who never read them; nor was he ever able to obtain a private audience although a minister of state.

Such is the account of his last conduct in office which is given by his friends; and as we have not read his treatises on the calamities of France, we have no right to controvert it. From his known principles, however, we are intitled to conclude, that his plans of reformation were similar to those of Neckar, the offspring rather of a head teeming with visionary theories, than of the enlightened mind of a practical statesman, or the corrupt heart of a Jacobin conspirator.

Perceiving the inutility of his endeavours, disgusted with what he thought the repeated errors of the government, and deprived of every means of exposing them, or preventing their fatal effects; after frequent solicitations, he at length obtained leave to retire. He repaired to his estate at Malesherbes, and from that moment entirely devoted his time to those occupations that had ever formed the chief pleasure of his life. He passed the evenings and a great part of the night in reading and study.

In this tranquil state he was passing the evening of his days amidst his woods and fields, when the horrors of the Revolution brought him again to Paris. During the whole of its progress, he had his eyes constantly fixed on his unhappy sovereign, and, subduing his natural fondness of retirement, went regularly to court every Sunday, to give him proofs of his respect and attachment. He imposed it as a duty on himself to give the ministers regular information of the designs of the regicide faction *; and when it was determined to bring the king to trial, he voluntarily offered to be the defender of his master, in his memorable letter of the 11th of December 1792, that eternal monument of his loyalty and affection. His offer was accepted; and he pleaded the cause of the monarch with a strength of argument that nothing could have resisted but the bloodthirsty minds of a den of Jacobins. "What Frenchman (says a valuable writer), what virtuous man, of any country, can ever forget that affecting scene, when the respectable old man, penetrating, for the first time, into the prison of the Temple, melted into tears, on finding himself pressed in the arms of his king; and that still more affecting scene, when, entrusted with the most agonizing commission that a subject could possibly have to his sovereign, he threw himself at the feet of the innocent victim, while, suffocated with his sobs, his voice,

till

* Bertrand's Memoirs, vol. iii. chap. 31.

Malesherbes.

till re-animated by the courage of the virtuous Louis, was inadequate to announce the fatal sentence of death *.

Having discharged this painful and hazardous duty he once more returned to his country residence, and resumed his tranquil course of life. But this tranquillity was of short duration. About a twelvemonth afterwards, in the month of December 1793, the new-created members of the Revolutionary Committee of Paris came to reside with him, his son-in law, and his daughter, and apprehended the two latter as criminals. Left alone with his grandchildren, Malesherbes endeavoured to console the rest of his unfortunate family with the hopes which he himself was far from entertaining, when, the next day, the new formed guards arrived to apprehend him, and the whole of his family, even the youngest infants. This circumstance spread a general consternation throughout the whole department; for there was hardly a man in France, a few excepted, who did not revere the mild virtues of the last friend of the unfortunate king.

In this calamity Malesherbes preserved the undisturbed equanimity of virtue. His affability and good humour never forsook him, and his conversation was as usual, so that to have beheld him (without noticing his wretched guards), it seemed that he was travelling for his pleasure with his neighbours and friends. He was conducted the same night to the prison of the Madelonette with his grandson Louis Lepelletier, at the same time that his other grandchildren were separated into different prisons. This separation proving extremely afflicting to him, he earnestly solicited against it; and at length, on his repeated entreaties, they all met together once more at Port-Libre. They remained there but a short period. The son in-law of Malesherbes, the virtuous Lepelletier Rasambo, the first of them who was arrested, was ordered into another prison, and sacrificed a few days after. Malesherbes himself, his daughter, his grand-daughter, and her husband, were soon after all brought to the guillotine. They approached it with fortitude and serenity. It was then that his daughter addressed these pathetic words to Mademoiselle Sombreuil, who had saved the life of her own father on the 2d of September: "You have had the exalted honour to preserve *your* father—I have, at least, the consolation to die with *mine*."

Malesherbes, still the same, even to his last moments exhibited to his relations an example of fortitude. He conversed with the persons that were near him without bestowing the least attention on the brutalities of the wretches who tied his hands. As he was leaving the prison to ascend the fatal cart, he stumbled against a stone, and made a false step. "See (said he smiling), how bad an omen! A Roman in my situation would have been sent back again." He passed through Paris, ascended the scaffold, and submitted to death with the same unshaken courage. He died at the age of 72 years, 4 months, and 15 days. He had only two daughters, and the son of one of them alone remains to succeed. From this account of Malesherbes's behaviour at his last moments, we are inclined to believe that his intentions were better than some parts of his practical conduct; and we know, that having dispelled the vain illusions of philosophism, he acknowledged his past errors; exclaiming, in the accents of grief, "That false philosophy (to which I confess I was myself a dupe) has plunged us into the gulph of destruction, and, by an inconceivable magic, has fascinated the eyes of the nation, and made us sacrifice reality to a mere phantom. For the simple words *political liberty*, France has lost that *social freedom* which she possessed in every respect, in a higher degree, than any other nation! How truly great did the king appear in his last moments! All their efforts to degrade him were vain; his unshaken virtue triumphed over their wickedness. It is true, then, that religion alone transfuses sufficient courage into the mind of man, to enable him to support, with so much dignity, such dreadful trials †.

† Bertram Memoirs, chap. 4.

Malguzzary. Malphaghino.

MALGUZZARY, in the language of Bengal, *payment* of revenue; the *revenue* itself.

MALPHAGHINO (John), otherwise called John de Ravenna, from the place of his birth, was born in the year 1352, of a family distinguished neither by riches nor nobility. His father, however, committed him to the care of Donatus the grammarian, an intimate friend of Petrarch, who at that time taught the Latin tongue with great applause at Venice. Donatus thought he discovered such happy dispositions in young Malphaghino, that he recommended him to Petrarch, not only as an excellent assistant to facilitate his labours, by reading or transcribing for him, but as a youth of the most promising talents, and worthy of being formed under the inspection of the greatest man of the fourteenth century.

It appears from some of Petrarch's letters, for it is from these chiefly we can obtain information respecting John de Ravenna, that he fully answered the expectations formed of him; and that he even gained the favour and affection of his patron so much, that he loved him and treated him as if he had been his own son. In a letter to John de Certaldo (A), Petrarch highly extols him, not only for his genius and talents, but also for his prudent and virtuous conduct. "He possesses (says he) what is very rare in our times, a great turn for poetry, and a noble desire to become acquainted with every useful and ornamental part of knowledge. He is favoured by the Muses, and already attempts verses of his own; from which one can foretel, that, if his life be spared, and if he goes on as hitherto, something great may be expected from him."

Not long, however, after this panegyric was written, young Malphaghino conceived an insuperable desire to see the world; and, notwithstanding all Petrarch's remonstrances, persisted in his resolution of quitting him. Petrarch's paternal care and regard for his pupil appear, on this occasion, in the most favourable light, as may be seen in his letters to Donatus; and his whole behaviour, though the young man insisted on leaving him, without assigning a sufficient reason for his precipitate and ungrateful conduct, does as much honour to his head as to his heart.

The precipitation with which John de Ravenna carried his plan into execution was not likely to make it answer his expectations. He departed without taking with him letters of recommendation which Petrarch offered him to his friends. He, however, pursued his journey over the Appenines, amidst continual rain, giving out that he had been dismissed by Petrarch; but, though he experienced from many a compassion to which he was not entitled by his conduct he now began to awaken from his dream. He proceeded therefore to Pisa.

(A) Better known under the name of *Boccaccio* or *Boccace*. Certaldo was the place of his birth.

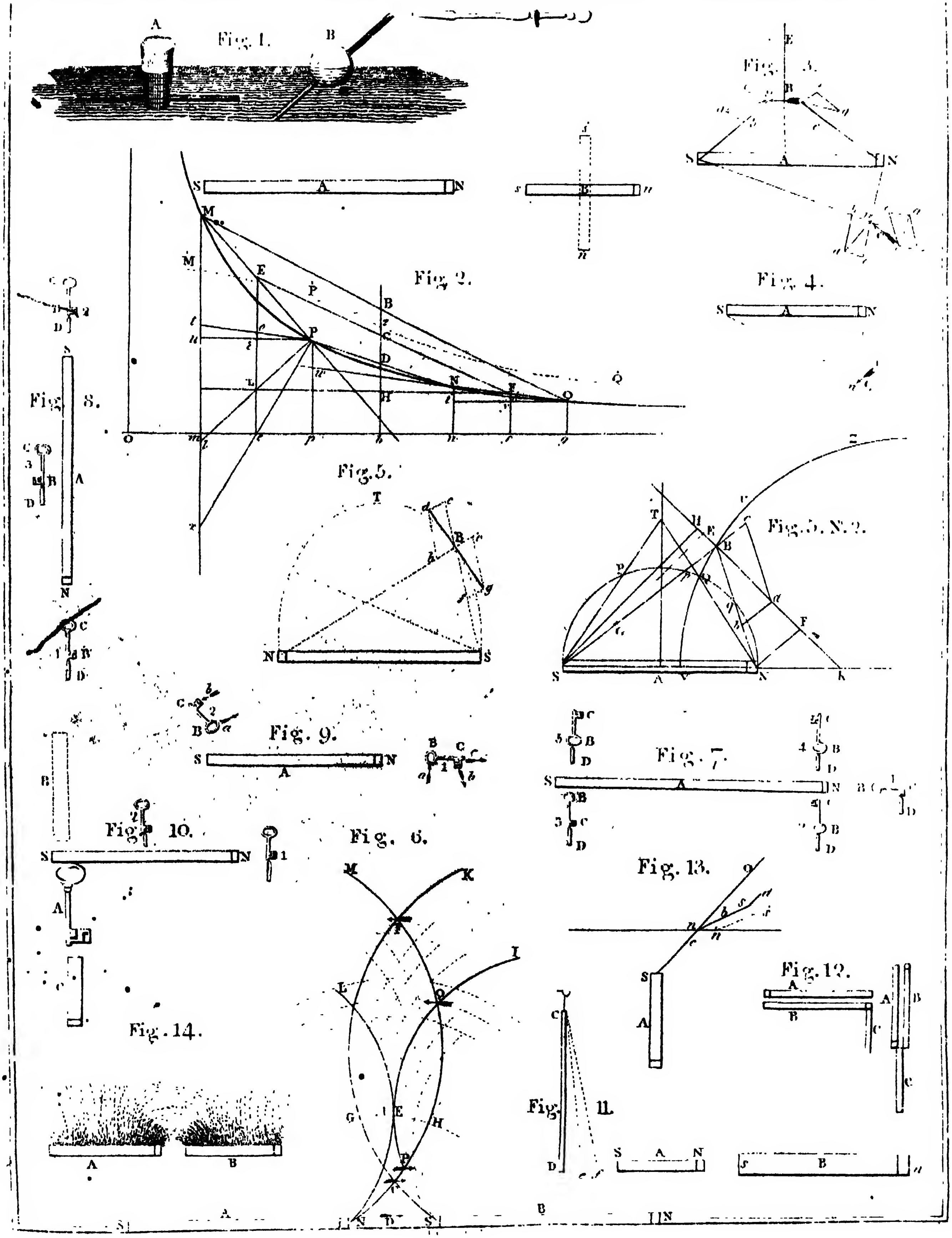
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 5. N. 2.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.

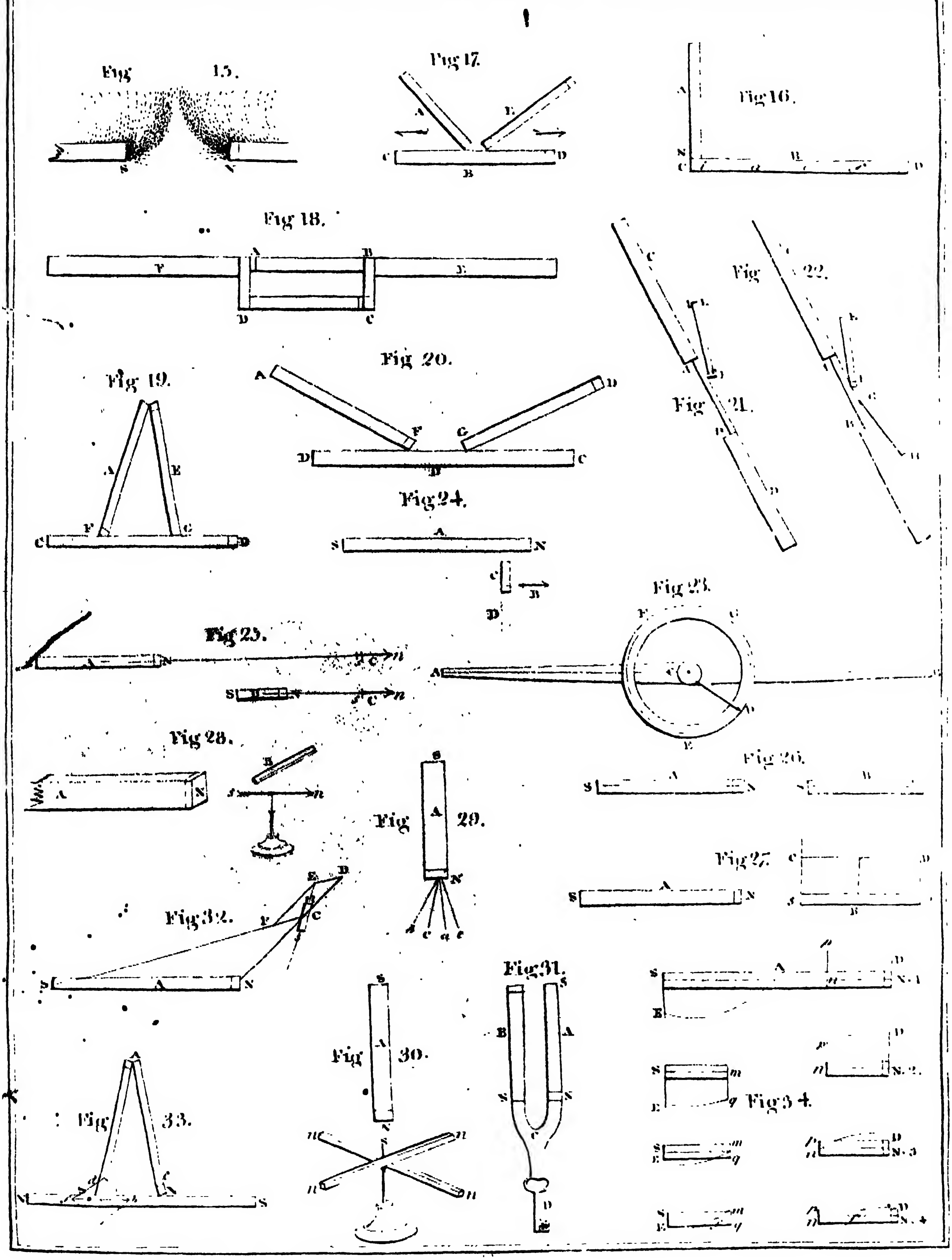
Fig 15.
Fig 17.
Fig 16.
Fig 18.
Fig 22.
Fig 20.
Fig 19.
Fig 21.
Fig 24.
Fig 23.
Fig 25.
Fig 28.
Fig 26.
Fig 29.
Fig 27.
Fig 32.
Fig 31.
Fig 34.
Fig 30.
Fig 33.

Pisa, in order to procure a vessel to carry him back to Pavia: but being disappointed, while his money wasted as much as his patience decreased, he suddenly resolved to travel back across the Appenines. When he descended into the Ligurian plains, he attempted to wade through a river in the district of Parma, which was much swelled by the rains; and being carried by the force of the stream into a whirlpool, he would have lost his life, had he not been saved by some people who were accidentally passing that way. After escaping this danger, he arrived, pennyless and famished, at the house of his former patron, who happened then not to be at home; but he was received and kindly entertained by his servants till their master returned.

Petrarch, by his intreaties and paternal admonitions, retained the young man at his house for about a year, and prevented him from engaging in any more romantic adventures; but, at the end of that period, his desire for rambling again returned; and as Petrarch found that all attempts to check him would be fruitless, he gave him letters of recommendation to two of his friends, Hugo de St Severino and Franciscus Brunus, at Rome. To the former of these, Petrarch says, "This youth of rare talents, but still a youth, after proposing to himself various plans, has at length embraced the noblest; and as he once travelled, he is now desirous of doing so again, in order to gratify his thirst of knowledge. He has, in particular, a strong inclination for the Greek language; and entertains a wish which Cato first conceived in his old age. This wish I have endeavoured for some years to subdue; sometimes by intreaties, at other times by admonition; sometimes by representing how much he is still deficient in the Roman language; and sometimes by laying before him the difficulties which must attend him in his journey, especially as he once before left me, and by want was obliged to return. As long as that unfortunate excursion was fresh in his memory he remained quiet, and gave me hopes that his restless spirit could be overcome and restrained. But now, since the remembrance of his misfortunes is almost obliterated, he again sighs after the world; and can be retained neither by force nor persuasion. Excited by a desire which betrays more ardour than prudence, he is resolved to leave his country, friends, and relations, his aged father, and me whom he loved as a father, and whose company he preferred to a residence at home, and to hasten to you whom he knows only by name. This precipitation even has an appearance of prudence. The young man first wished to visit Constantinople; but when I told him that Greece, at present, is as poor as it was formerly rich in learning, he gave credit to my assertion, and at any rate altered his plan, which he could not carry into execution. He is now desirous of traversing Calabria, and the whole coast of Italy, distinguished formerly by the name of Magna Graecia, because I once told him that there were in that quarter several men well skilled in the Greek language, particularly a monk, Barlaam, and one Leo, or Leontius with whom I was intimately acquainted, and of whom the first had been some time my scholar. In consequence of this proposal, he begged me to give him a recommendatory letter to you, as you have considerable influence in that part of the country. This request I granted, in hopes that the young man, by his genius and talents, will afford you satisfaction equal to the service which you may render to him." In his letter to Brunus, Petrarch expresses himself as follows: "He is a young man who wishes to see the world as I formerly did; but I never reflect on it without horror. He is desirous of seeing Rome; and this desire I cannot condemn, as I myself have so often visited that city, and could still revisit it with pleasure. I suspect, however, that he will venture on a more extensive ocean, and that he imagines to find a fortune where he will, perhaps, meet with a shipwreck. At any rate, he is desirous, he says, of putting his fortune to a trial. I wish it may be favourable; should it be adverse, he is still at liberty to return to my peaceful, though small, haven; for I hang out a light, during the day as well as the night, to guide those who quit me through youthful folly, and to enable them to find their way back. The ardour by which he is impelled must not be ascribed so much to him as to his age, and is in itself commendable. If I am not much deceived, the young man loves me and virtue in general. He is unsteady, but modest; and deserves that all good men should contribute to his prosperity as far as they can."

From the letters of Petrarch, there is reason to believe, that John de Ravenna lived with him only about three years in all; and that he had not attained to the full age of manhood when he left him. It appears also, for this circumstance is very obscure, that after he quitted him, he wandered about a considerable time before he was so fortunate as to meet with a protector and patron, at whose house, as he wrote to Petrarch, he at last found a permanent asylum. How long he remained with his patron, whom some believe to have been Cardinal Philip, and what happened to him till the death of Petrarch in 1374, and for some years after, is unknown. The literary monuments of the fourteenth and fifteenth centuries say nothing farther of him till his appearance at Padua; where, according to the testimony of Sicco (B), one of the most celebrated of his scholars, he not only taught the Roman Eloquence, but also the science of moral philosophy, with such success and applause, and improved his scholars so much by his life and example, that, according to universal opinion, he far excelled all the professors of those sciences who had ever before appeared. That he was here of considerable service in reviving the study of the Latin language, and of the works of the ancient Romans, was acknowledged by all his scholars, and is confirmed by the following testimony of Blondus (C).

"About the same period, Ravenna produced that

(B) Adolescens tum ego poetas, et instituta Tullii audiebam. Legebat tunc hac in civitate Padua, literarum nutrice, *Johannes Ravennas* vir et sanctimonia morum, et studio isto excellens, atque si potest sine invidia, dici ceteris, qui magistri artis hujus in terra Italia usquam degerent et doctissimi haberentur, quantum recordari valeo, omnium judicio præferendus. Hoc namque a præceptore non eloquentia modo, quam ex ordine legerit sed mores etiam, ac quædam bene honesteque vivendi ratio cum doctrina tum exemplis discebatur. —*Sicco Polentonus*, Ap. Mehus, l. c. p. 139.

(C) Blondi Flavii Forliviensis Italia illustrata. Bas. 1559. fol. p. 346.

Malphag-hino.

learned grammarian and rhetorician Johannes, of whom Leonardus Aretinus uſed to ſay, that he firſt introduced into Italy, after a long period of barbariſm, the ſtudy of the Latin language and eloquence, now ſo flouriſhing; a circumſtance which deſerves to be enlarged on in the preſent work. Thoſe well acquainted with Roman literature know, that after the periods of Ambroſe, Jerom, and Auguſtine, there were none, or very few, who wrote with any elegance, unleſs we add to theſe good writers, St Gregory, the venerable Bede, and St Bernard. Francis Petrarcha was the firſt who, with much genius, and ſtill greater care, recalled from the duſt the true art of poetry and of eloquence. He did not attain to the flowers of Ciceronian eloquence, with which many are adorned in the preſent century; but this was owing rather to a want of books than of talents. Though he boaſted of having found at Vercelli Cicero's letters to Lentulus, he was unacquainted with the books of that great Roman *De Oratore*, Quintilian's Inſtitutes, the *Orator*, the *Brutus*, and other writings of Cicero. John de Ravenna was known to Petrarch both in his youth and in his old age. He was not more converſant with the ancients than Petrarch; and, as far as I know, left no works behind him. By his excellent genius, however, and, as Leonardus Aretinus ſays, by the particular diſpenſation of God, he was the preceptor of this Leonardus, of Petrus Paulus Vergerius, of Annebonus de Padua, of Robert Roſſi, of James Angeli of Florence, of Poggius and Guarino of Verona, of Victorinus, Sicco, and other men of leſs note, whom he incited to the ſtudy of better knowledge, and to imitate Cicero, if he could not form them or inſtruct them completely.

"About the ſame time, Manuel Chryſoloras, a man as virtuous as learned, came from Conſtantinople to Italy, and inſtructed in the Greek language, partly at Venice and partly at Florence and Rome, all the before mentioned ſcholars of John de Ravenna. After he had continued this inſtruction for ſome years, thoſe unacquainted with the Greek language, and the ancient Greek writers, were conſidered in Italy as more ignorant than thoſe unacquainted with the Latin. A great many young men and youths were inflamed with an enthuſiaſtic deſire for the works of the ancient Greeks and Romans. At the time of the council of Conſtance, in the beginning of the fifteenth century, many of my countrymen endeavoured, by ſearching the neighbouring cities and convents, to diſcover ſome of the Roman manuſcripts which had been loſt. Poggius firſt diſcovered a complete copy of Quintilian, which was ſoon followed by the letters of Cicero to Atticus. As our youth applied to the ſtudy of theſe works with the utmoſt diligence, that celebrated grammarian and rhetorician Caſparinus de Bergamo, opened a ſchool at Venice, ſuperior to the former, and in which young perſons were encouraged to ſtudy the ancient languages and writers. About the ſame time flouriſhed Petrus Paulus Vergerus, Leonerdus Aretinus, Robert Roſſi, James Angeli, Poggius, and Nicolaus de Medici, whom Aretin had long inſtructed. Guarinus alſo had begun to inſtruct many at Venice, and Victorinus at Mantua, when Philip III. Duke of Milan, recalled Caſparinus as his ſubject, from Venice to Padua and Milan. The increaſing ſtudy of ancient literature was much promoted by Gerard Landriano biſhop of Lodi, diſcovering under ſome ruins an old copy of Cicero, written in characters ſcarcely legible, which, among other rhetorical writings of that great Roman, contained the whole books *De Oratore*, with his *Brutus* and *Orator*. This ſaved Caſparinus the trouble of ſupplying the books of Cicero *De Oratore*, as he had attempted to ſupply the works of Quintilian. As no one was found in all Milan who could read this old manuſcript of Cicero, an ingenious young man of Verona, named Caſmus, was ſo fortunate as firſt to tranſcribe the books *De Oratore*, and to fill all Italy with copies of a work which was univerſally ſought for with the utmoſt avidity. I myſelf, in my youth, when I went to Milan on the buſineſs of my native city, tranſcribed, with as much ardour as ſpeed, the *Brutus* of Cicero, and ſent copies of my tranſcription to Guarinus at Verona, and to Leonard Juſtiniani at Venice; by which means this work was ſoon diſperſed all over Italy. By theſe new works eloquence acquired new fire; and hence it happens, that in our age people ſpeak and write better than in the time of Petrarch. The ſtudy of the Greek language, beſides the abundance of new and uſeful knowledge which it diſcloſed, was attended with this great advantage, that many attempted to tranſlate Greek works into Latin, and thereby improved their ſtyle much more than they could have done without that practice. After this period, ſchools for teaching the ancient languages increaſed in Italy, and flouriſhed more and more. Moſt cities had ſchools of this kind; and it gives one pleaſure to obſerve, that the ſcholars excelled their maſters, not only when they left them, but even while they were under their tuition. Of the ſcholars of John de Ravenna, two of the oldeſt, Guarinus and Victorinus, the former at Venice, and the latter at Mantua, Verona, Florence, and Ferrara, inſtructed an immenſe number of pupils; and among theſe, the Princes of Ferrara and Mantua. George of Trebiſonde, when he lectured at Rome, had for his auditors, beſides Italians, many French, Spaniards, and Germans, among whom ſometimes there were men of rank and eminence. Franciſcus Philelphus, who had been taught at Conſtantinople by Chryſoloras himſelf, inſtructed a great many young men and youths in the Greek and Latin languages at Venice, Florence, Siena, Bologna, and, laſt of all, at Milan." In the above quotation, the ſhare which John de Ravenna had in reviving and diffuſing a knowledge, not only of the Roman, but alſo of the Grecian literature, is ſo clearly repreſented, that no farther teſtimony is neceſſary to eſtabliſh his claim to celebrity.

After John de Ravenna had taught at Padua, he removed for the like purpoſe to Florence; where, as appears, he inſtructed young people for ſome time, without being expreſsly invited by the government, and without being publicly paid for his labours. In the beginning of his reſidence at Florence, he ſeems to have been recommended by Colucius to the learned Charles de Malateſta. "There lives here at preſent (ſays Colucius, in one of his letters) a teacher of great merit, John de Ravenna.—He is (continues he) of mature age; irreproachable in his manners, and ſo diſpoſed in general, that if you receive him, as I hope and wiſh, among the number of your intimate friends, you will find him an agreeable and incomparable aſſiſtant to you in your labours and ſtudies. What can be more deſirable to you than to poſſeſs a man who will lucubrate and labour for you? and who, in a ſhort time, can communicate to you what you could not obtain by your

own exertions without great difficulty. I do not know whether you will find his like in all Italy; and I therefore wish, that, if you confide in my judgment, you will receive John de Ravenna in the room of your late learned friend James de Alegretti." It is not known whether John de Ravenna went to reside with Malatesta or not. It is, however, certain, that the former, in 1397 (the same year in which Mannel Chrysoloras came to Florence), was invited thither by the magistrates of that city, with the promise of an annual salary, to instruct young people in the Roman language and eloquence; that John de Ravenna, at the period when he entered into this honourable engagement, was 45 years of age; and that the scholars of John de Ravenna were, at the same time, scholars of Chrysoloras. Saluratus Colucius, in all probability, was the cause of this invitation, as he was acquainted with the services of John de Ravenna, and knew how to appreciate them. "We know (says he, in one of his letters to John de Ravenna), and all who respect you know also, that none of the moderns, or even ancients, approached so near to Cicero as you; and that to the most wonderful beauty and powers of speech, you join the deepest knowledge." John de Ravenna, like Chrysoloras, and most of the teachers of the Greek and Roman languages in the beginning of the fifteen century, was, no doubt, engaged at first only for a few years; when these were elapsed, the engagement was renewed, perhaps for the last time, in 1412, and he was bound, besides teaching the Roman eloquence, to read publicly, and explain in the cathedral, on festivals, the poems of Dante. John de Ravenna did not long survive the above renewal of his engagement; for an anonymous writer, who, in 1420, finished *A Guide to Letter-writing, according to the Principles of John de Ravenna*," speaks of his preceptor as of a man not then in existence.

MALT. See BREWING (*Encycl.*), where a full account is given of Sir Robert Murray's method of malt-making, together with some valuable observations on malt by Mr Richardson of Hull. In a late edition of this latter gentleman's *Theoretic Hints on Brewing*, we are told, that Mr Edward Rigby of Norwich is of opinion, that the mere exsiccation of corn is not the only object obtainable by drying it on the kiln, but that some portion of the saccharum of malt is the effect of that process. "The operation of kiln-drying the malt (says Mr Rigby) is as follows:—The grain is spread thick upon a floor made of flat bricks (*tiles*), or iron plates, which are full of perforations; immediately under this floor is the oven or furnace, in which is a large fire made of *coaks*, cinders, or, in some places, billet wood; a current of air, at the mouth of the furnace, keeps up the combustion of the coaks, and the air which is phlogisticated by their burning, and which, in a common fire place, rises up the chimney, passes, in this instance, through the apertures in the floor, and penetrates the whole stratum of malt before it can pass into the external air. Under these circumstances, it is evident, that the interstices of the malt must be filled with phlogistic air; and as the grain usually remains in this situation about two days, it is obvious, that if it have the power of absorbing phlogiston, it certainly must do it when so long in contact with it. And that the malt does really imbibe some of this principle, is not only probable on the general ground of the truth of the preceding theory, but, I believe, it will be found, that the phlogisticated air which rises from the burning substances underneath, is corrected in passing through the malt; for without its being meliorated by this or some other cause, it is evident that the air in the kiln-chamber, more especially the lower strata of it, must be noxious, and probably even so much so as to be unfit for respiration and combustion. But so far from this being the case, I am informed, that workmen will lie and sleep many hours on the malt in this situation without suffering any inconvenience. And after mentioning this, it is scarcely necessary to add, that I find also, by experiment, that a candle will burn perfectly well in the air which is immediately on the surface of the malt.

"Were heat alone sufficient for the purpose of completing the operation of malting, it certainly might be applied in a much more cheap way than is at present done; for the floor on which the grain is laid might, unquestionably, be heated equally without there being perforations in it, as with them. In which case, one kind of fuel would be as good as another; and, consequently, the present expence of previously burning the coals, to convert them into coaks or cinders, might be saved.

"But, admitting that the application of phlogiston to the malt, as well as heat, is requisite in this operation, the necessity of these perforations becomes evident, and also the propriety of previously burning the coals in such a way, that all the water, and those other heterogeneous particles which compose smoke and soot, may be dissipated; for these, merely as such, would obviously contribute little to the phlogistication of the malt, and would evidently impart some offensive flavour, if not some obnoxious quality to it.

"Reasoning from the above premises (Mr Rigby concludes), it would seem, that as all the farinaceous parts of the barley are seldom dissolved in brewing, and the grains which are left have usually the disposition to become sour, thereby manifesting some of the acid principle to be still existing in them, it is not improbable but some further saccharine matter might be obtained from the grain by another exposure to phlogisticated air, or, in other words, by being once more laid on the kiln."

This is indeed so far from being improbable, that we think it must infallibly be the case. Sugar, it is well known, consists of oxygen, hydrogen, and carbon (see CHEMISTRY in this *Supplement*, n° 466.); but from the disposition of the grains to become sour, it is plain, that after the process of brewing they still retain much oxygen; and the azotic gas, which is here called phlogisticated air, there is every reason to believe contains both hydrogen and carbon. These, therefore, uniting with the oxygen of the grains, must make an addition to the saccharine matter. This has, indeed, been found to be the fact by Mr Richardson, who, in consequence of Mr Rigby's suggestion, was induced to brew a small brewing of malt, of ten quarters only, and stopping the process when, according to his general practice, one extract was still due, he ordered the grains to be laid upon one of his malt-kilns, and cinders to be applied the same as for drying of malt. This was continued for two days and a half, when the grains, being perfectly dried, were put into sacks, and, when cold, returned again into the mash-tun. The event, in some measure, justified Mr

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Rigby's expectation; for the produce of fermentable matter was considerably more than he had reason to expect, than would have been the case, had the extract been made in immediate succession, as it would have been in the ordinary course of his practice. He attempts, indeed, to account for it in a way very different from ours; but though we have the highest confidence in Mr Richardson as an experienced brewer, we must sometimes beg leave to think for ourselves as chemists. Like a man of sense, however, and a man of science, he says, "I am so well satisfied with the event of this experiment, that I shall probably be inclined, on some future occasion, to repeat it, in various stages of the process. The fine lively froth on the surface of the wort, in the underback, added to its transparency and good flavour, are circumstances which induce me to thank Mr Rigby for the hint, which, it is not improbable, may be applied to some useful purpose, in certain situations which sometimes occur in the brewing trade."

MAMMALUKES, MAMALUCS, *Mamelouces*, or *Mamluks*, were a dynasty that reigned for a considerable time in EGYPT, and of which some account has been given in that article (*Encycl.*). A fuller account of them must, however, be acceptable to our readers, as, since the expedition of Buonaparte, they have attracted the attention of all Europe.

They were first introduced into Egypt, as we have already observed, by Saladine, who, when he had it in contemplation to besiege Jerusalem, very naturally endeavoured to collect the most forcible means to accomplish so desirable an end; and, in consequence, observing that the ancient inhabitants of Egypt were, from their effeminate mode of education, and the quiet and tranquil habits of their lives, much fitter for those occupations in which they delighted, namely, the arts, merchandize, and mechanics, than military tactics and military toil, he resolved, as little as possible, to employ or depend upon them.

This resolution stimulating him to procure a hardier race of soldiers he therefore commissioned agents to treat with the Circassians, by the Lake of Mæotis, near Tawrica Chersonesus, whence, about the year 1176, they purchased more than a thousand slaves. Men inured to hardship, nurtured in the lap of toil and danger, and bred from their infancy to war, which was to them rather an instinct than a science, as the continual incursions of the Tartars rendered self defence, in their situation, absolutely necessary.

These slaves Saladine trained to military discipline, and, at the same time that he made them renounce Christianity, had them instructed in the Mahometan religion; and although he prohibited them from marrying, he allowed them an unbounded licence with respect to desultory gallantry. What progress they made in the doctrines of the Alcoran, whether the tenets of that sacred volume effectually eradicated all their first principles, is uncertain; but it is certain, that in time they became excellent soldiers, and that the military glory of Saladine, which was feebly supported by the native Egyptians, expanded in the hands of the Mamelouces, who extended their conquests on every side, until, pervading the Holy Land, they entered in the plain of Askelon.

These Mamelouces, who were continually adding to their numbers, in process of time became naturalized to the country; and, as it has been observed, they excelled the Egyptians in strength of body, in military discipline, in their skill in horsemanship, and in courage; so they, by the liberality of their generals, and the plunder of cities and provinces, also excelled them in wealth. In fact, their mode of education fitted them for the most dangerous and adventurous enterprises, and, from being the slaves, enabled them in time to become the masters of even the Turks, by whom they had originally been purchased.

After the death of Saladine, who left the kingdom to his brother, they rose to still greater importance than they had acquired during his reign, and continued, if not absolutely to govern, yet, like the Roman soldiers in the time of Pertinax, Alexander, and Valerian, to awe the monarch.

This influence continued through the reigns of five successive Caliphs, until that of Melachsala, the last of the posterity of Saladine, who being at war with the Arristians, and, at the same time, wishing to repress the enormous power of the Mamelouces, purchased slaves from all the surrounding countries, whom, in imitation of his ancestor, he armed and appointed to defend his dominions. The event of this measure was exactly what might have been expected. Melachsala was, in consequence of a conspiracy betwixt his new and his old soldiers, slain; and Turquemenus, the leader of this mutiny and rebellion, hailed by the title of Great Sultan of Egypt. With him began the government of the Mamelouces, about the year 1250; which had the next year gathered such strength, that it was thought necessary, in order to repress those exuberances to which new formed governments are liable, and bring it nearer to a system, to cause the following articles, in the form of a charter, to be subscribed to by their principal leaders, as an act of the whole people:—"1st, That the Soltan should be chosen from the body of Mamelouces; 2dly, That none should be admitted into the order that were by birth either Jews or Turks, but only Christian captives; 3dly, That the native Egyptians should not be permitted to use, or have, any weapons, except the instruments of agriculture."

Turquemenus, as is frequently the practice with those that experience a sudden elevation, endeavoured to kick down the ladder by which he had been raised; or, in other words, his carriage was so haughty and disdainful to his former companions, that he was by them, or rather by one of them named Clotho, suddenly slain; for which the murderer was rewarded with his sceptre. After him succeeded a long race of princes, many of whom were as eminent for their talents as for their valour; among whom, the name of Caitbeius has been transmitted to us as that of the greatest statesman and general of his age; but, as every one who considers the *materials* of which the government was composed, must rather wonder that it existed so long, than that it should, through almost the whole course of its operation, be exposed to all the various evils and distresses arising from a long train of sedition and tumults, so he must lament that it should expire in the reign of one of their wisest and best monarchs: yet it is some consolation to reflect, that Campson, the last Sultan of the Mamelouces, was not *murdered by his own subjects*, but having for many years governed the kingdoms of Egypt, Judea, and Syria, in a manner that has excited the praise of

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of the hiſtoric pen, he, oppreſſed with age and diſeaſe, and encumbered with his armour, ſunk upon the field of battle, and, with his laſt breath, yielded the victory to the fortunate Selim.

With this monarch, who expired January 20, 1516, [illegible] the government of the Mamelouces, after it had continued 276 years; for although an attempt was made by Tomumby to get himſelf declared Sultan, in which attempt he actually ſucceeded ſo far as to be inveſted with the title, yet he was ſoon after defeated by the victorious Selim. He was then forſaken by his troops, taken and executed; while the Mamelouces, broken and diſperſed, it was the policy of Selim to rally, and, by offers too tempting to be by them refuſed, engage in his ſervice. The uſe of theſe ſoldiers ſoon became ſufficiently apparent to the Turkiſh Emperors, to ſtimulate them to augment their number, enlarge their ſphere of action, and combine them cloſer to the ſtate, by the allowance of ſtill greater privileges and advantages than they had before enjoyed.

The Beys were ordained to be choſen from among them; and the Paſha, or chief governor for the Porte, was to ſhare his power with thoſe Beys, and even to continue in office no longer than ſhould be agreeable to their collective will. At firſt the power of the Paſha was very extenſive; but, by the intrigues and ambition of the Beys, it has been reduced almoſt to a cypher. It was rather of a civil than military nature. He was always preſident of the Divan, which was held in the caſtle where he reſided. But that council now commonly meets in the palace of one of the chief Beys, except when a firman or mandate is received from Conſtantinople, when the Beys are ſummoned to the caſtle, to hear the commands of the Porte. The few who attend, as ſoon as the reading is finiſhed, anſwer, as is uſual, "*Eſmana wa taana*," "We have heard, and we obey." On leaving the caſtle, their general voice is "*Eſmana wa aaſina*," "We have heard, and ſhall diſobey."

In the year 1791, Salah Aga, a ſlave of Murad Bey, was deputed from the government of Egypt to negociate their peace with the Porte. He carried preſents of horſes, rich ſtuffs, &c. A ſpontaneous tribute, which the Porte was in no condition to enforce, implied obligation on the part of the latter. He was well received, and afterwards was appointed *Waquil es Sultan*, agent or attorney to the Sultan in Cairo. It is probable, this office was given him to incline him to ſecond the efforts of the Court in diſuniting the Beys; but it was ineffectual. Theſe had formerly experienced the evils of diviſion, and now were united by common intereſt, grown rich, and well provided with ſlaves; ſo that no tribute has ſince that time found its way to Conſtantinople.

The Mamelouces remain, as they have ever been, military ſlaves, imported from Georgia, Circaſſia, and Mingrelia. A few have been priſoners, taken from the Auſtrians and Ruſſians, who have exchanged their religion for an eſtabliſhment. The Beys give general orders to their agents at Conſtantinople, to purchaſe a certain number every year; and many are brought to Egypt by private merchants on ſpeculation. When the ſupply proves inſufficient, or many have been expended, black ſlaves from the interior of Africa are ſubſtituted, and, if found docile, are armed and accoutred like the reſt.

Particular attention is paid to the education of theſe favoured ſlaves. They are inſtructed in every exerciſe of agility or ſtrength, and are, in general, diſtinguiſhed by the grace and beauty of their perſons. The gratitude of the diſciples is equal to the favour of their maſters, whom they never quit in the hour of danger. If they have a diſpoſition for learning, they are taught the uſe of letters, and ſome of them are excellent ſcribes; but the greater part neither can read nor write. A ſtriking example of which deficiency is obſervable in Murad Bey himſelf.

The inferior Mamelouces conſtantly appear in the military dreſs, and are commonly armed with a pair of piſtols, a ſabre, and a dagger. They wear a peculiar cap of a greeniſh hue, around which is wreathed a turban. The reſt of their dreſs reſembles that of other Mohamedan citizens, and is reſtricted to no particular colour; but another ſingularity is, their large drawers of thick Venetian cloth, of a crimſon colour, to which are attached their ſlippers of red leather. On horſeback they add to their arms a pair of large horſe piſtols, and the dubbus or battle-axe. In battle, many of them wear an open helmet, and the ancient ring armour of interwoven links of ſteel, worn under part of their dreſs, and thus concealed. Theſe are dear; ſometimes coſting 500 piaſtres, or about L. 50. Some of them are made at Conſtantinople, others in Perſia. Their horſes are of the fineſt Arabian breed, and are often purchaſed at three or four purſes, L. 150 to L. 200 ſterling.

They have no pay, as they eat at a table in the houſe of their maſter the Bey, Caſhef, or other officer. Any military officer may purchaſe a ſlave, who becomes, *ipſo facto*, a Mamelouc. The name, from *malk*, to poſſeſs, implies merely a perſon who is the property of another. After a proper education, the candidate thus conſtituted a Mamelouc, receives a preſent of a horſe and arms from his maſter, together with a ſuit of clothes; which is renewed every year in the month Ramadan. The generoſity of their maſters, and rewards or extortions from others, afford them ſupplies of money, either for avarice or debauchery. Some of them, admitted to peculiar favour by the Beys, as chaſnadars, or purſe-bearers, &c. acquire great wealth. They are rather gay and thoughtleſs than inſolent, fond of ſhow, and unprincipled in their means of acquiring it. They ſeldom marry till they acquire ſome office.

Though born of Chriſtian parents, they ſeem highly ſatisfied with their condition, which they have been known to refuſe to exchange for freedom. The majority are regarded by the Arabs as little ſtrict in the principles or duties of Mohamediſm. It is worthy of remark, that though the Mamelouces, in general, be ſtrong and perſonable men, yet the few who marry very ſeldom have children. As the ſon, even of a Bey, is not honoured with any particular conſideration, the women, perhaps, procure abortions. Of eighteen Beys, with whoſe hiſtory Mr Browne was well acquainted, two only had any children living.

Hardy, capable of every fatigue, of undaunted courage, and eminent ſkill in horſemanſhip and the uſe of the ſabre, the Mamelouces may be regarded as by far the beſt troops in the Eaſt. But in a regular battle, conducted by manœuvres, and large or rapid movements, they are equally inferior to European troops.

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Being distinguished by favouritism or merit, the Mameluke becomes a Cashef, and in time a Bey. The chief cause of preference arises from political adherence to some powerful leader.

The government of Cairo, and Egypt, in general, is vested in 24 Beys; each of whom is nominally chosen by the remaining 23, but, in fact, appointed by one of the most powerful. The Yenk-tchery, Aga, and several other officers, are enumerated among the 24 Beys.

Besides being governors of certain districts of Egypt, several of the Beys receive other dignities from the Porte: Such are the Shech el Bellad or governor of the city; the Defterdar, or accountant-general; the Emir el Hadj, or leader of the sacred caravan; and the Emir es Said, or governor of the Upper Egypt. These two last offices are annual. These officers have also revenues allotted them by the Porte, ill defined, and liable to much abuse.

Of the other Beys, each appoints all officers and governors within his district, putting into it some slave of his own, who is compelled to render an account of the receipts, of which a great part passes to support the grandeur of his master. An opulent Bey may have from 600 to 1000 purses annually; the revenue of Murad Bey more than doubles that sum. The inferior Beys may have 300 purses, or L. 15,000.

Every Bey sits in judgment on cases of equity. These personages are very observant of their respective jurisdictions; and no Bey will imprison a man liberated by another. Though sometimes too impetuous, they nevertheless display great acuteness and knowledge of characters. This government, at least, possesses every advantage of publicity, as every Bey is a magistrate.

MAN, has been considered in a great number of particulars under the title MAN (*Encycl.*); but a reference was made from that article to the article *Varieties of the Human Species*, which was, after all, omitted entirely.

Perhaps enough has been said on the varieties of the human species in the articles COMPLEXION and NEGRO (*Encycl.*); but as infidel ignorance is perpetually pretending, that the diminutive Icelanders, the ugly Esquimaux, the woolly-headed Negro, and the copper-coloured American, could not have descended from one original pair, either of European complexion or of Hindoo symmetry—it may not be improper, in this place, to shew the weakness of this popular objection to the Mosaic history of the origin of man. This has been done in so satisfactory a manner by Professor Blumenbach, that we have nothing to do but lay his observations before our readers, convinced, as we are, that they are intelligible to every capacity, and that they will carry conviction to all who are not the slaves of prejudice.

Phil. Mag. vol. iii. p. 284.

"Some late writers on natural history (says the Professor) seem doubtful whether the numerous distinct races of men ought to be considered as mere varieties, which have arisen from degeneration, or as so many species altogether different. The cause of this seems chiefly to be, that they took too narrow a view in their researches; selected, perhaps, two races the most different from each other possible, and, overlooking the intermediate races that formed the connecting links between them, compared these two together; or, they fixed their attention too much on man, without examining other species of animals, and comparing their varieties and degeneration with those of the human species. The first fault is, when one, for example, places together a Senegal negro and an European Adonis, and at the same time forgets that there is not one of the bodily differences of these two beings, whether hair, colour, features, &c. which does not gradually run into the same thing of the other, by such a variety of shades, that no physiologist or naturalist is able to establish a certain boundary between these gradations, and consequently between the extremes themselves.

"The second fault is, when people reason as if man were the only organised being in nature, and consider the varieties in his species to be strange and problematical, without reflecting that all these varieties are not more striking or more uncommon than those with which so many thousands of other species of organised beings degenerate, as it were, before our eyes."

As what we have said under the articles COMPLEXION and NEGRO may be sufficient to warn mankind against the first error, and at the same time to refute it, we hasten to refute the second by our author's comparison between the human race and that of swine.

"More reasons (says he) than one have induced me to make choice of swine for this comparison; but, in particular, because they have a great similarity, in many respects, to man: not, however, in the form of their entrails, as people formerly believed, and therefore studied the anatomy of the human body purposely in swine; so that, even in the last century, a celebrated dispute, which arose between the physicians of Heidelberg and those of Durlach, respecting the position of the heart in man, was determined, in consequence of orders from government, by inspecting a sow, to the great triumph of the party which really was in the wrong. Nor is it because in the time of Galen, according to repeated assertions, human flesh was said to have a taste perfectly similar to that of swine; nor because the fat, and the tanned hides of both, are very like to each other; but because both, in regard to the economy of their bodily structure, taken on the whole, shew unexpectedly, on the first view, as well as on closer examination, a very striking similitude.

"Both, for example, are domestic animals; both *omnivora*; both are dispersed throughout all the four quarters of the world; and both consequently are exposed, in numerous ways, to the principal causes of degeneration arising from climate, mode of life, nourishment, &c.; both, for the same reason, are subject to many diseases, and, what is particularly worthy of remark, to diseases rarely found among other animals than men and swine, such as the stone in the bladder; or to diseases exclusively peculiar to these two, such as the worms found in measled swine.

"Another reason (continues he) why I have made choice of swine for the present comparison is, because the degeneration and descent from the original race are far more certain in these animals, and can be better traced, than in the varieties of other domestic animals. For no naturalist, I believe, has carried his scepticism so far as to doubt the descent of the domestic swine from the wild boar; which is so much the more evident, as it is well known that wild pigs, when caught, may be easily rendered as tame and familiar as domestic swine: and the contrary also is the case; for if the latter by any accident get into the woods, they as readily become wild again; so that there are instances of such animals

animals being shot for wild swine; and it has not been till they were opened, and found castrated, that people were led to a discovery of their origin, and how, and at what time, they ran away. It is well ascertained, that, before the discovery of America by the Spaniards, swine were unknown in that quarter of the world, and that they were afterwards carried thither from Europe. All the varieties, therefore, through which this animal has since degenerated, belong, with the original European race, to one and the same species; and since no bodily difference is found in the human race, as will presently appear, either in regard to stature, colour, the form of the cranium, &c. which is not observed in the same proportion among the swine race, while no one, on that account, ever doubts that all these different kinds are merely varieties that have arisen from degeneration through the influence of climate, &c. this comparison, it is to be hoped, will silence those sceptics who have thought proper, on account of these varieties in the human race, to admit more than one species.

"With regard to stature, the Patagonians, as is well known, have afforded the greatest employment to anthropologists. The romantic tales, however, of the old travellers, who give to these inhabitants of the southern extremity of America a stature of ten feet and more, are scarcely worth notice; and even the more modest relations of later English navigators, who make their height from six to seven feet, have been doubted by other travellers, who, on the same coast, sought for such children of Enoch in vain. But we shall admit every thing said of the extraordinary size of these Patagonians by Byron, Wallis, and Carteret; the first of whom assigns to their chief, and several of his attendants, a height of not less than seven feet, as far as could be determined by the eye; the second, who asserts that he actually measured them, gives to the greater part of them from 5 feet 10 inches to 6 feet; to some 6 feet 5 inches, and 6 feet 6; but to the tallest, 6 feet 7 inches: and this account is confirmed by the last-mentioned of the above circumnavigators. Now, allowing this to be the case, it is not near such an excess of stature as that observed in many parts of America among the swine, originally carried thither from Europe; and of these I shall mention in particular those of Cuba, which are more than double the size of the original stock in Europe.

"The natives of Guinea, Madagascar, New Holland, New Guinea, &c. are black; many American tribes are reddish brown, and the Europeans are white. An equal difference is observed among swine in different countries. In Piedmont, for example, they are black. When I passed (says our author) through that country, during the great fair for swine at Salenge, I did not see a single one of any other colour. In Bavaria, they are reddish brown; in Normandy, they are all white.

"Human hair is, indeed, somewhat different from swine's bristles; yet, in the present point of view, they may be compared with each other. Fair hair is soft, and of a silky texture; black hair is coarser, and among several tribes, such as the Abyssinians, Negroes, and the inhabitants of New Holland, it is woolly, and most so among the Hottentots. In the like manner, among the white swine in Normandy, as I was assured by an incomparable observer, Sulzer of Ronneburg, the hair on the whole body is longer and softer than among other swine; and even the bristles on the back are very little different, but lie flat, and are only longer than the hair on the other parts of the body. They cannot, therefore, be employed by the brush-makers. The difference between the hair of the wild boar and the domestic swine, particularly in regard to the softer part between the strong bristles, is, as is well known, still greater.

"The whole difference between the cranium of a Negro and that of an European, is not in the least degree greater than that equally striking difference which exists between the cranium of the wild boar and that of the domestic swine. Those who have not observed this in the animals themselves, need only to cast their eye on the figure which Daubenton has given of both.

"I shall pass over (says our author) less national varieties which may be found among swine as well as among men, and only mention, that I have been assured by Mr Sulzer, that the peculiarity of having the bone of the leg remarkably long, as is the case among the Hindoos, has been remarked with regard to the swine in Normandy. 'They stand very long on their hind legs (says he, in one of his letters); their back, therefore, is highest at the rump, forming a kind of inclined plane; and the head proceeds in the same direction, so that the snout is not far from the ground.' I shall here add, that the swine, in some countries, have degenerated into races which in singularity far exceed every thing that has been found strange in bodily variety among the human race. Swine with solid hoofs were known to the ancients, and large herds of them are found in Hungary, Sweden, &c. In the like manner, the European swine, first carried by the Spaniards, in 1509, to the island of Cuba, at that time celebrated for its pearl fishery, degenerated into a monstrous race, with hoofs which were half a span in length."

From these facts, our author concludes, that it is absurd to allow the vast variety of swine to have descended from one original pair, and to contend that the varieties of men are so many distinct species.

MANDING, a large state in the interior of Africa, of which the only satisfactory account that we have is by Mr Park, who, for several months, was hospitably entertained in Kamalia, one of its towns, situated in 12° 40′ N. Lat. and 6° 40′ W. Long. The government of Manding appeared to our author to be a sort of republic, or rather an oligarchy. Every town is indeed governed by a chief magistrate called Mansa, which usually signifies king; but the chief power of the state, in the last resort, is lodged in the assembly of these mansas (A). The case, however, is different in other countries, which are occupied by people who have emigrated from Manding; for in all the Mandingo states near

(A) Mr Park, for the most part, writes with remarkable perspicuity; but we are not sure that here we have not mistaken his meaning. He says, that the chief power of the state is lodged in the assembly of that *whole body*; but we think, that by the whole body must be meant the body of *Mansas*, otherwise the government could not be called an oligarchy.

near the Gambia, the government is monarchical, tho' the power of the sovereign is by no means unlimited.

As Mr Park's route was confined to a tract of country, bounded nearly by the 12th and 15th parallels of latitude, the climate throughout the whole was nearly the same as that of Manding, and extremely hot: Yet, where the country ascended into hills, he found it comparatively cool and pleasant; though none of the districts which he traversed could be called mountainous. About the middle of June, the hot and sultry atmosphere is agitated by violent gusts of wind (called *tornadoes*), accompanied with thunder and rain. These usher in what is denominated *the rainy season*; which continues until the month of November. During this time, the diurnal rains are very heavy; and the prevailing winds are from the south-west. The termination of the rainy season is likewise attended with violent tornadoes; after which the wind shifts to the north east, and continues to blow from that quarter during the rest of the year.

When the wind sets in from the north-east, it produces a wonderful change in the face of the country. The grass soon becomes dry and withered; the rivers subside very rapidly, and many of the trees shed their leaves. About this period is commonly felt the *harmattan*, a dry and parching wind, blowing from the north east, and accompanied by a thick smoky haze; through which the sun appears of a dull red colour. This wind, in passing over the great desert of Sahara, acquires a very strong attraction for humidity, and parches up every thing exposed to its current. It is, however, reckoned very salutary, particularly to Europeans, who generally recover their health during its continuance. The truth of this our author experienced both at Kamalia and Pisania, when he had been brought to the very brink of the grave by sickness.

Whenever the grass is sufficiently dry, the negroes set it on fire; but in Ludamar, and other Moorish countries, this practice is not allowed; for it is upon the withered stubble that the Moors feed their cattle until the return of the rains. The burning of the grass in Manding exhibits a scene of terrific grandeur. "In the middle of the night (says Mr Park), I could see the plains and mountains, as far as my eye could reach, variegated with lines of fire; and the light reflected on the sky, made the heavens appear in a blaze. In the day time, pillars of smoke were seen in every direction; while the birds of prey were observed hovering round the conflagration, and pouncing down upon the snakes, lizards, and other reptiles, which attempted to escape from the flames." This annual burning is soon followed by a fresh and sweet verdure, and the country is thereby rendered more healthful and pleasant.

Though many species of the edible roots, which grow in the West India islands, are found in Africa, yet our traveller never saw, in any part of his journey, either the sugar cane, the coffee, or the cocoa tree; nor could he learn, on inquiry, that they were known to the natives. The pine-apple, and the thousand other delicious fruits which the industry of civilized man (improving the bounties of nature), has brought to so great perfection in the tropical climates of America, are here equally unknown. He observed, indeed, a few orange and banana trees, near the mouth of the Gambia; but whether they were indigenous, or were formerly planted there by some of the white traders, he could not positively learn.

Concerning property in the soil, it appeared to Mr Park, that the lands in native woods were considered as belonging to the king, or (where the government was not monarchical) to the state. When any individual of free condition had the means of cultivating more land than he actually possessed, he applied to the chief man of the district, who allowed him an extension of territory, on condition of forfeiture if the lands were not brought into cultivation by a given period. The condition being fulfilled, the soil became vested in the possessor; and, for aught that appeared, descended to his heirs.

The Mandingoes are a very gentle race of people; cheerful in their dispositions, inquisitive, credulous, simple, and fond of flattery. The men are commonly above the middle size, well shaped, strong, and capable of enduring great labour; the women are good natured, sprightly, and agreeable. The dress of both sexes is composed of cotton cloth of their own manufacture; that of the men is a loose frock, not unlike a surplice, with drawers which reach half way down the leg; and they wear sandals on their feet, and white cotton caps on their heads. The womens dress consists of two pieces of cloth, each of which is about six feet long and three broad; one of these they wrap round the waist, which, hanging down to the ancles, answers the purpose of a petticoat; the other is thrown negligently over the bosom and shoulders. Both men and women among the Mandingoes seem to have an invincible propensity to commit depredations on the property of unprotected strangers; whilst such is the good nature of those poor heathens, that they will readily sympathise in the sufferings, relieve the distresses, and contribute to the personal safety, of the very strangers whom they are bent upon plundering.

Among the Mandingoes, the parental and filial affection is remarkably strong between the mother and her child; but not so between the father and his children. This, as Mr Park observes, is easily accounted for. The system of polygamy, while it weakens the father's attachment, by dividing it among the children of different wives, concentrates all the mother's jealous tenderness to one point, the protection of her own offspring. He perceived, with great satisfaction too, that the maternal solicitude extended, not only to the growth and security of the person, but also, in a certain degree, to the improvement of the mind of the infant; for one of the first lessons in which the Mandingo women instruct their children, is *the practice of truth*.

The Mandingo women suckle their children until they are able to walk of themselves. Three years nursing is not uncommon; and during this period, the husband devotes his whole attention to his other wives. To this practice it is owing, that the family of each wife is seldom very numerous. Few women have more than five or six children. As soon as an infant is able to walk, it is permitted to run about with great freedom. The mother is not over solicitous to preserve it from slight falls, and other trifling accidents. A little practice soon enables a child to take care of itself, and experience acts the part of a nurse. As they advance in life, the girls are taught to spin cotton, and to beat corn, and are instructed in other domestic duties; and the

Mandingoes.

the boys are employed in the labours of the field. Both ſexes, whether Buſhreens or Kafirs, on attaining the age of puberty, are circumciſed. This painful operation is not conſidered by the Kafirs ſo much in the light of a religious ceremony, as a matter of convenience and utility. They have, indeed, a ſuperſtitious notion, that it contributes to render the marriage ſtate prolific.

When a young man takes a fancy to a young girl, and wiſhes to marry her, it is by no means conſidered as neceſſary that he ſhould make an overture to the girl herſelf. The firſt object is to agree with the parents, concerning the recompence to be given them for the loſs of the company and ſervices of their daughter. The value of two ſlaves is a common price, unleſs the girl is thought very handſome; in which caſe, the parents will raiſe their demand very conſiderably. If the lover is rich enough, and willing to give the ſum demanded, he then communicates his wiſhes to the damſel: but her conſent is by no means neceſſary to the match; for if the parents agree to it, and eat a few *kolla nuts*, which are preſented by the ſuitor as an earneſt of the bargain, the young lady muſt either have the man of their choice, or continue unmarried, for ſhe cannot afterwards be given to another. If the parents ſhould attempt it, the lover is then authoriſed, by the laws of the country, to ſeize upon the girl as his ſlave. At the celebration of a marriage, no religious ceremony ſeems to be practiſed. A ſelect number of people are indeed invited to the wedding, and feaſted; but conſummation conſtitutes the marriage; for towards the morning, the new married couple are always diſturbed by the women, who aſſemble to inſpect the nuptial ſheet (according to the manners of the ancient Hebrews, as recorded in Scripture), and dance round it. This ceremony is thought indiſpenſably neceſſary; nor is the marriage conſidered as valid without it.

The Mandingoes, and indeed all the negro ſtates, whether Mahomedan or Pagan, allow a plurality of wives. The conſequence is, that the wives frequently quarrel among themſelves. When this happens, the huſband decides between them; and ſometimes finds it neceſſary to adminiſter a little corporal chaſtiſement before tranquillity can be reſtored. But if any one of the ladies complains to the chief of the town, that her huſband has unjuſtly puniſhed her, and ſhewn an undue partiality to ſome other of his wives, the affair is brought to a public trial. In theſe *palavers*, however, which are conducted chiefly by married men, our author was informed, that the complaint of the wife is not always conſidered in a very ſerious light; and the complainant herſelf is ſometimes convicted of ſtrife and contention, and left without remedy. If ſhe murmurs at the deciſion of the court, the magic rod of *Mumbo Jumbo* ſoon puts an end to the buſineſs. See Mumbo Jumbo in this *Suppl*.

A child, among them, is named when it is ſeven or eight days old. The ceremony commences by ſhaving the infant's head; and a diſh called *degu*, made of pounded corn and ſour milk, is prepared for the gueſts. If the parents are rich, a ſheep or a goat is commonly added. This feaſt is called *ding koon lee*, "the child's head ſhaving." During Mr Park's ſtay at Kamalia, he was preſent at four different feaſts of this kind, and the ceremony was the ſame in each, whether the child belonged to a Buſhreen or a Kafir. The ſchoolmaſter, who officiated as prieſt on thoſe occaſions, and who is neceſſarily a Buſhreen, firſt ſaid a long prayer over the *dega*; during which, every perſon preſent took hold of the brim of the calabaſh with his right hand. After this, the ſchoolmaſter took the child in his arms, and ſaid a ſecond prayer; in which he repeatedly ſolicited the bleſſing of God upon the child, and upon all the company. When this prayer was ended, he whiſpered a few ſentences in the child's ear, and ſpat three times in its face; after which he pronounced its name aloud, and returned the infant to the mother. This part of the ceremony being ended, the father of the child divided the *dega* into a number of balls, one of which he diſtributed to every perſon preſent. And inquiry was then made, if any perſon in the town was dangerouſly ſick, it being uſual, in ſuch caſes, to ſend the party a large portion of the *dega*, which is thought to poſſeſs great medical virtues.

The Mandingoes have no artificial method of dividing time. They calculate the years by the number of *rainy ſeaſons*. They portion the year into *moons*, and reckon the days by ſo many *ſuns*. The day they divide into morning, mid day, and evening; and further ſubdivide it, when neceſſary, by pointing to the ſun's place in the heavens. Our author frequently inquired of ſome of them, what became of the ſun during the night, and whether we ſhould ſee the ſame ſun, or a different one, in the morning? But that ſubject appeared to them as placed beyond the reach of human inveſtigation; they had never indulged a conjecture, nor formed any hypotheſis, about the matter. The moon, by varying her form, has more attracted their attention. On the firſt appearance of the new moon, which they look upon to be newly created, the Pagan natives, as well as Mahomedans, ſay a ſhort prayer; and this ſeems to be the only viſible adoration which the Kafirs offer up to the Supreme Being. This prayer is pronounced in a whiſper; the party holding up his hands before his face: its purport is to return thanks to God for his kindneſs through the exiſtence of the paſt moon, and to ſolicit a continuation of his favour during that of the new one. At the concluſion, they ſpit upon their hands, and rub them over their faces. Great attention is paid to the changes of this luminary in its monthly courſe; and it is thought very unlucky to begin a journey, or any other work of conſequence, in the laſt quarter. An eclipſe, whether of the ſun or moon, is ſuppoſed to be effected by witchcraft. The ſtars are very little regarded; and the whole ſtudy of aſtronomy appears to them as a uſeleſs purſuit, and attended to by ſuch perſons only as deal in magic.

Their notions of geography are equally puerile. They imagine that the world is an extended plain, the termination of which no eye has diſcovered; it being, they ſay, overhung with clouds and darkneſs. They deſcribe the ſea as a large river of ſalt water, on the farther ſhore of which is ſituated a country called *Tobaubo doo*: "the land of the white people." At a diſtance from Tobaubo doo, they deſcribe another country, which they allege is inhabited by cannibals of gigantic ſize, called *Kcomi*.

Mr Park ſays he has converſed with all ranks and conditions of negroes on the ſubject of their faith, and that he can pronounce, without the ſmalleſt ſhadow of doubt, that the belief of one God, and of a future ſtate of reward and puniſhment, is entire and univerſal among them.

Manding. them. It is remarkable, however, that, except on the appearance of a new moon, as before related, the Pagan natives do not think it neceſſary to offer up prayers and ſupplications to the Almighty. They repreſent the Deity, indeed, as the creator and preſerver of all things; but in general they conſider him as a Being ſo remote, and of ſo exalted a nature, that it is idle to imagine the feeble ſupplications of wretched mortals can reverſe the decrees, and change the purpoſes, of unerring wiſdom. The concerns of this world, they believe, are committed by the Almighty to the ſuperintendance and direction of ſubordinate ſpirits, over whom they ſuppoſe that certain magical ceremonies have great influence. A white fowl, ſuſpended to the branch of a particular tree, a ſnake's head, or a few handfuls of fruit, are offerings which ignorance and ſuperſtition frequently preſent, to deprecate the wrath, or to conciliate the favour, of theſe tutelary agents.

The Mandingoes ſeldom attain extreme old age. At forty, moſt of them become grey haired, and covered with wrinkles; and but few of them ſurvive the age of fifty-five, or ſixty. Yet their diſeaſes appeared but few; fevers and fluxes being the moſt common, and the moſt fatal. For theſe they generally apply *ſaphies*, i. e. charms, to different parts of the body; though ſometimes, on the firſt attack of a fever, the patient is, with great ſucceſs, placed in a ſort of vapour bath. The other diſeaſes which prevail among the negroes, are the *yaws*, the *elephantiaſis*, and a *leproſy* of the very worſt kind, together with the *Guinea worm*, which they attribute to bad water.

When a perſon of conſequence dies, the relations and neighbours meet together, and manifeſt their ſorrow by loud and diſmal howlings. A bullock or goat is killed for ſuch perſons as come to aſſiſt at the funeral; which generally takes place in the evening of the ſame day on which the party died. The negroes have no appropriate burial places, and frequently dig the grave in the floor of the deceaſed's hut, or in the ſhade of a favourite tree. The body is dreſſed in white cotton, and wrapped up in a mat. It is carried to the grave, in the duſk of the evening, by the relations. If the grave is without the walls of the town, a number of prickly buſhes are laid upon it, to prevent the wolves from digging up the body; but our author never obſerved that any ſtone was placed over the grave as a monument or memorial.

With reſpect to employment, the men cultivate the ground, or catch fiſh in large rivers; while the women manufacture cotton cloth. It is only the ſpinning and the dyeing, however, that are performed by the women; for the web, which is ſeldom more than four inches broad, is wove by the men in a loom made exactly upon the ſame principle as that of Europe. As the arts of weaving, dyeing, ſewing, &c. may eaſily be acquired, thoſe who exerciſe them are not conſidered in Africa as following any particular profeſſion; for almoſt every ſlave can weave, and every boy can ſew. The only artiſts which are diſtinctly acknowledged as ſuch by the negroes, and who value themſelves on exerciſing appropriate and peculiar trades, are the manufacturers of leather and of iron. The firſt of theſe are called *Karrankea* (or as the word is ſometimes pronounced *Gaungay*). They are to be found in almoſt every town, and they frequently travel through the country in the exerciſe of their calling. They tan and dreſs leather with very great expedition, by ſteeping the hide firſt in a mixture of wood-aſhes and water, until it parts with the hair; and afterwards by uſing the pounded leaves of a tree, called *goo*, as an aſtringent.

The manufacturers in iron are not ſo numerous as the *Karrankeas*; but they appear to have ſtudied their buſineſs with equal diligence. The negroes on the coaſt being cheaply ſupplied with iron from the European traders, never attempt the manufacturing of this article themſelves; but in the inland parts, the natives ſmelt this uſeful metal in ſuch quantities, as not only to ſupply themſelves from it with all neceſſary weapons and inſtruments, but even to make it an article of commerce with ſome of the neighbouring ſtates. During our author's ſtay at Kamalia, there was a ſmelting furnace at a ſhort diſtance from the hut where he lodged, and the owner and his workmen made no ſecret about the manner of conducting the operation; and readily allowed him to examine the furnace, and aſſiſt them in breaking the iron-ſtone. The proceſs it is needleſs to deſcribe; though it be proper to obſerve, that the maſs of metal obtained by it was rather ſteel than iron. Moſt of the African blackſmiths are acquainted alſo with the method of ſmelting gold, in which proceſs they uſe an alkaline ſalt, obtained from a ley of burnt corn-ſtalks evaporated to dryneſs. They likewiſe draw the gold into wire, and form it into a variety of ornaments, ſome of which are executed with a great deal of taſte and ingenuity.

The reader will obſerve, that in the extracts which we have made from Mr Park's intereſting travels, the terms African and Negro are frequently uſed as if all Africans and Negroes were Mandingoes. The reaſon is, that the Mandingoes were not only the moſt numerous tribe which he viſited, but were alſo ſpread over all that tract of country which he traverſed.

MANIANA, a ſmall negro kingdom lying between 12° and 14° North Lat. and between the meridian of Greenwich and 1° and 30′ Weſt Long. Its inhabitants, as Mr Park was informed by a variety of people in many different kingdoms, are remarkable for cruelty and ferocity; carrying their reſentment to their enemies ſo far as never to give quarter, and even indulging themſelves with banquets of human fleſh. Hence the inhabitants of Bambarra, who carried on with them a long and bloody war, and muſt of courſe be well aſcertained of the fact, call them *Ma dummulo*, which ſignifies meneaters.

MANURE is ſo eſſential to agriculture, that the want of it, or an improper manner of uſing it, is the principal cauſe of the ſterility of a country. We have therefore treated of manures and their action at ſome length in the article AGRICULTURE in the *Encyclopædia*; but as the theoretical part of that diſquiſition reſts in a great meaſure on the doctrine of phlogiſton, which is now exploded, it may not be improper to reſume the ſubject here. Experience, however being, after all, the only guide which the farmer can ſafely and confidently follow, inſtead of amuſing our readers with theories of our own, we ſhall lay before them the obſervations of a man who ſeems to have united theory with practice.

"The uſe of manures (ſays M. Parmentier *) has been known in all ages, but we are yet far from having any clear and preciſe ideas of the nature of the juices which

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which are destined for the nourishment of vegetables, and of the manner in which they are transmitted to their organs. The writers on agriculture, who have endeavoured to explain these matters, perceiving salts in most plants, were persuaded that these salts, by the help of water and heat, passed, in a saline form, through the vegetable filter. These first philosophers did not hesitate to consider every thing that has been done by the industry of man, to improve the nature of land, and its productions, as merely forming reservoirs of these salts, which they considered as the principle of fertility. This opinion was so well established among the improvers of land, that, to this day, many of them have no object in view, in their operations, but to disengage salts; and, when they attempt to explain certain phenomena which take place in their fields or orchards, they talk confidently about the *nitre of the air, of rain, of snow, of dew, and fogs;* of the *salts of the earth, of dung, of marle, of lime, of chalk,* &c. and make use of those vague terms, *oil, sulphur, spirit,* &c. which ought henceforward to be banished from our elementary books on agriculture.

"Among the authors who have attacked, and combated with most success, the opinion that the fruitfulness of soils, and the aliment of vegetables, reside in saline substances, must be reckoned Eller and Wallerius. These philosophers examined, by every means which chymistry at that time could furnish, the various kinds of earth proper for cultivation, and also those substances which have always been considered as the most powerful manures, without being able to obtain, from any of them, any thing more than mere atoms of salt.

"Animated with the same zeal, and taking advantage of the instructions found in their writings, I thought it necessary to determine, by experience, whether, as has been asserted, there really exist neutral salts in earths; and also, whether those earths are more fertile in proportion to the quantity of such salts they contain. With this view, I lixiviated, by means of distilled water, many species of cultivated earths, taken in various states, from fresh earth to that which had been impoverished by the growth of several crops; I also tried dung, reduced more or less into the state of mould; and likewise the most active manures, such as the offal of animal substances rotted by putrefaction; but in none of these, however carefully analyzed, were found any salts in a free state. They contain indeed the materials proper for forming salts, but if they contain any ready formed, it is merely by accident.

"The researches of Kraft, and those of Althof, were not attended with different results. Having sown some oats in ashes, not lixiviated, and in sand strongly impregnated with potash and with saltpetre, and having found that the oats did not grow, they concluded that neutral salts, and alkalies, not only retarded the growth of vegetables, but that they absolutely prevented it. It is well known that in Egypt there are districts where the earth is entirely covered with sea-salt, and these districts are quite barren. It is probably owing to this property of sea-salt, that the Romans were accustomed to scatter large quantities of it over fields where any great crime had been committed, and of which they wished to perpetuate the remembrance, by rendering the part barren for a certain time.

"The idea that salts had great influence in vegetation, ought to have been greatly weakened by the following simple reflection. Supposing that salts existed in garden mould, they would be very soon dissolved by the rain, and carried away, towards the lower strata of the earth, to a depth to which the longest roots would not reach. Indeed the famous experiment of Vanhelmont would have been sufficient to have destroyed the above opinion, if it did not generally happen that we are no sooner set free from one error than we fall into another not less extraordinary. The surprising effects of vegetation brought about by the overflowing of water, and in the neighbourhood of salt marshes, and the infinite number of inhaling capillary tubes observed upon the surface of vegetables, led to an opinion that the air and water, absorbed by the roots and leaves of plants, were only vehicles loaded with saline matter, analogous to the vegetables nourished by them.

"To the experiment of Vanhelmont, which was repeated by many accurate observers, succeeded those of modern philosophers; from which it clearly appeared, that plants could grow, and produce fruit, in the air of the atmosphere, and in distilled water, also in pure sand, in powdered glass, in wet moss or sponge, in the cavity of fleshy roots, &c. and that plants which had nothing but the above-mentioned fluids for their nourishment, gave, when submitted to chymical analysis, the same products as those which had undergone their process of vegetation in a soil perfectly well manured. It was also observed, that the most barren soils were rendered fertile when they were properly supplied with water by canals; and the efficacy of irrigation was repeatedly evinced in different ways: from these observations was formed the following system, that water rises in plants in the form of vapour, as in distillation; that air introduces itself into their pores; and that, if salts contribute to the fruitfulness of soils, it is only in consequence of their containing the two fluids above mentioned in great abundance."

Our author, after making many experiments upon various soils and salts, and after attending minutely to the process of vegetation, thinks himself warranted to maintain, "that saline substances have no sensible effects in promoting vegetation, except inasmuch as they are of a deliquescent nature, have an earthy basis easily decomposed, and are used only in small quantity. In those circumstances they have the power of attracting, from the immense reservoir of the atmosphere, the vapours which circulate in it; these vapours they retain, along with the moisture that is produced from rain, snow, dew, fog, &c. which moisture they prevent from running together in a mass, or from being lost, either by exhaling into the air of the atmosphere, or by filtering itself through the inferior strata of the earth, and thereby leaving the roots of vegetables dry; they distribute that moisture uniformly, and transmit it, in a state of great division, to the orifices of the tubes destined to carry it into the texture of the plant, where it is afterwards to undergo the laws of assimilation. As every kind of vegetable manure possesses a viscous kind of moisture, it thereby partakes of the property of deliquescent salts. In short, the preparation of land for vegetation has no other object in view but to divide the earthy particles, to soften them, and to give them a form capable of producing the above mentioned effects. It is sufficient, therefore, that water, by its mixture with

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Such was the opinion which our author gave of the manner in which salts act in vegetation, at a time when it was not known that air and water (which had been so long considered as elements), far from being simple substances, are capable of being decomposed by a great variety of operations both of nature and art; and nothing was wanting to complete his theory, but to know that air and water act their part in vegetation only in a state of decomposition; and that if earth well manured is a better matrix than water itself, it is because such earth has the power of converting the water into gases which are easily absorbed, and which, while their absorption takes place, communicate to the plants a motion and heat which they received when taking the form of gas, and which they lose when they enter again into combination; whence it is natural to conclude, that this motion and this heat must necessarily develope themselves in seeds, and maintain the vital action in plants.

What is a vegetable, considered chemically, according to the present state of our knowledge? It is, say the chemists, a compound of hydrogen, oxygen, and carbon, the proportions of which vary according to the agents which have concurred to its developement, and according to the matrix which received and assimilated them, in order to create those combinations which are varied to infinity, by their forms and properties, and known by the generic terms of salt, oil, and mucilage. It appears, therefore, needless to seek these combinations in the different substances which are used for manure, when we wish to determine the nature of them, and explain their manner of acting in vegetation; because, supposing it true that these salts, these oils, or these mucilages, exist in their combined state, nothing but their constituent elements, namely, hydrogen, oxygen, and carbon, can possibly have any action.

The superiority of animal substances, as manures, and the remarkable luxuriance of those plants which are watered with putrid water, prove incontestibly, that the putrid state is favourable to vegetation, and that every substance which is liable to enter, to a certain degree, into that state, contributes very powerfully thereto. The most aerated waters are, in this case, the most beneficial. It is observed that rain, particularly in stormy weather, quickens vegetation so much, that the gardeners in the neighbourhood of Paris are often obiged to drench their plants with water taken from their wells, which, in consequence of its rawness, or its want of air, retards the vegetation of the plants; either because it precipitates the meteorised or electrified water, or because, by being mixed with the other water, it diminishes its fertilizing quality; whereas, in summer, this same well water, by being exposed to the sun for some days, acquires a smell like that of stale eggs, loses its rawness, and becomes very fit for accelerating vegetation. An atom of vegetable or animal matter is, at that time, sufficient to bring about more quickly this state of putrefaction; while these same substances, by being employed in certain proportions, far from acting as a leaven on the liquids which hold them in solution, preserve those liquids, or at least make them more slow to change.

Salts and dung, therefore, are not merely decomposed by the power of vegetation; by furnishing the results of their decomposition, they also act in the manner of leavens, the action of which is scarcely perceptible in cold or dry weather; but when they are heated by the sun, and sufficiently penetrated with moisture, they very soon enter into a sort of fermentation, suffering the various gases with which they are provided to escape. Thus manures may be considered as decomposing instruments, provided by nature, and prepared by art, to act upon water so as to bring it to a proper state of attenuation. The substances which enter into the composition of plants are, therefore, nothing but products of the decomposition of air and water, and combinations of the constituent principles of these two fluids, determined by the power which presides in the seed, and which thence has passed into the plant.

It is now easy to account for the effects of charcoal-powder, straw, &c which are made use of to cover ground during long droughts with undoubted benefit: they are mechanical means of preventing the dissipation of moisture, and of determining it to take the form of those gaseous fluids which have such powerful effect in vegetation. As water is composed of hydrogen and oxygen, it is not surprising that, when assisted by the influence of the sun, and that of electricity, it is capable of forming, almost by itself, the solids and fluids of vegetables; taking from the atmosphere the carbon it stands in need of, to give them their most essential characters. We say their most essential characters; for those terrestrial plants which have grown in air and water do not abound in principles, and their offspring, when they have any, is by no means vigorous. We see also, that plants which are naturally of an aquatic nature, have in general but little smell, because the medium in which they live and grow furnishes only a small quantity of carbon, in proportion to the hydrogen and oxygen, which are the constituent principles of water. This is the reason why, in cold and wet years, flowers are less odoriferous, fruit less full of flavour, and more difficult to be preserved. The germ of their reproduction is weak; and they are, if the expression may be used, in a sort of dropsy; that is to say, they are loaded with the principles which constitute water, and even with water itself.

These observations, to which more might be added, may serve to explain why vegetation is slow and weak in a soil which is too much charged with saline matter, while it is rendered quick and vigorous by a small quantity of this same matter; and why earth, which is perfectly lixiviated, and watered, from time to time, with distilled water only, is capable of giving to bitter plants their bitterness, to sweet ones their sweetness, to acid ones their acidity, to aromatic ones their spiciness, and to poisonous ones their deleterious qualities; in short, why the inherent characters of plants are more strongly marked, in proportion as the soil in which they grow is furnished with natural or mechanical means to produce

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duce a quantity of gas necessary to the formation of the substances on which those characters depend.

If a nitrous or marine plant can, even when growing in a soil destitute of nitre or sea salt, occasion the production of these salts, it must be allowed that such plants would vegetate more strongly, and contain more of such salts, if they grew in soils more abounding in materials proper to form them. Thus, the different species of samphire, glasswort, sea wrack, &c. flourish on the borders of the sea, such soils being strongly impregnated with the fluids necessary to form the muriatic gas and sea salt which enter into the composition of those plants; while the sun flower, pellitory, &c. succeed best in earth which is mixed with the ruins of old buildings, in which the materials for the production of nitrous gas, and even of nitre itself, are very abundant. In short, the organization of these plants is a real elaboratory for forming the forementioned salts.

Those plants which, for their vegetation, require the most assistance from the soil and manure, are very apt to contract a disagreeable taste, if either the soil or manure are capable of supplying the principles from which it is acquired. The class *tetradynamia*, particularly all sorts of cabbages (which contain sulphur ready formed), contract a bad taste in a soil composed of mud and dung, because these substances, as they are decomposed, furnish a great quantity of hepatic gas, or of sulphurised hydrogen gas; yet plants of another class may grow in the same soil, close by the cabbages, without partaking even in the smallest degree of the bad taste of the latter. The plants last mentioned, when growing in hepatic gas, retain only so much of it as is sufficient for the production of the substances of which they are formed; the overplus, which could not be assimilated, is thrown out by the excretory vessels, after undergoing those modifications which the digestive juices and organization of the plant, and the state of the atmosphere, have produced.

Thus we see that those plants which abound most in oily, saline, and mucilaginous principles, are generally such as require a soil well manured. Tobacco, for instance, gives forty pounds of alkaline salt or potash from every hundred weight of ashes: this plant may, by being buried in the ground, be converted into a very powerful manure; while other plants, which thrive in a middling soil, and appear as vigorous, are, in general, such as have not so great a quantity of principles in their composition, and when thrown on the dunghill, and left to rot, furnish very little manure. From such observations, it may perhaps not be impossible hereafter to judge, by the analysis of a plant, not only whether it requires a large or a small quantity of manure, but likewise what kinds of soil and manure are most fit to promote its vegetation: wild plants also may serve to shew the nature of the soil which they seem most to flourish in.

Besides the physical action of manures, they have a very evident mechanical action. When mixed with earth, in a certain proportion, they not only render it more permeable to water, but the roots of plants can, with greater ease, acquire their proper size and form in it: in other cases, manures tend to unite that earth which is too loose, and, by rendering it more tenacious, they prevent the water from being lost, and the roots from becoming dry. Those manures which are called *warm* are suited to cold lands, not only because they render them less compact, but also because they take off a part of that moisture which such lands always have in too great quantity. Cold manures, on the other hand, by their viscid quality, give tenacity to dry and hot soils, attracting and retaining, for a longer time, the moisture which comes in their way. The nature of the soil must therefore determine what kind of manure it stands in need of, and also whether cultivating it by means of oxen or by horses is preferable; for the manures produced from these two animals have those opposite qualities which we have above described. By such observations, we shall perhaps be able to resolve a question, respecting which the sentiments of cultivators in many parts of the kingdom are much divided.

It cannot, however, be denied, that the earth is able of itself to serve as a basis and support to plants, and that it has an action more or less evident upon air, upon water, and upon dung. There is a well-known method of distinguishing clay from other earths: by merely breathing upon it, a smell is immediately perceived, sufficiently strong to shew that a decomposition and fresh combination have taken place. In summer, after a drought of some days continuance, there always arises in the fields a particular smell during a shower of rain; and there is no kind of vegetable manure which, when mixed with earth, does not send forth a smell. This proves, that the nature of the soil must have an influence, not only upon air and upon water, but also upon the effect of manures; and that before we speak of their power, we should always specify what kind of earth they were applied to; because when manures and earth are mixed together, there ensues an action and reaction more or less favourable to vegetation.

Having examined to what degree air and water enter, in substance, into the vessels of plants, and having shewn that the principal action of earth, of salts, and of manures, consists in preparing, elaborating, and decomposing these two fluids, and in giving to the products of their decomposition the forms they require, to accomplish the purpose of nature in vegetation, our author makes some observations upon the particular effects of certain substances used for improving land, such as marl, lime, chalk, and wood ashes; which are usually applied either to an exhausted soil, in order to restore it, or to a drooping plant, with a view to give it strength. Of the efficacy of these substances no one doubts, but it does not appear that we are equally agreed respecting their manner of acting.

Marl (a manure whose effects are well known, and which is found to be of the greatest benefit in those districts where it can be procured in sufficient quantity) is capable of acting in the same manner as the most fertile soil, when the principles of which it is composed, namely, clay, sand, calcareous earth, and magnesian earth, are justly proportioned to each other. But it is sometimes compact and tenacious, because it contains a superabundant portion of clay, and at other times porous and friable, because it contains too much sand, and therefore is not in general fit for vegetation by itself. These considerations ought always to be our guide when we mean to employ marl as a manure.

It has been supposed that *to marl* was a sort of technical expression, intended to denote the bringing together

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"Wood-ashes, as a manure, may be, in some respects, compared to marl; at least they contain the same earths as those which generally enter into the composition of marl, but they contain a greater quantity of saline substances, proceeding from the vegetables of which they are the residue, and from the process made use of in their combustion; a process which increases their activity, and should render us careful in what manner and for what purposes we employ them. Wood ashes, when scattered over fields, at proper times and in proper quantities, destroy weeds, and encourage the vegetation of good plants. But do the ashes produce this effect by a sort of corrosive power? I cannot (says our author) think it; for in that case all kinds of plants would indiscriminately be acted upon by them, and to a certain degree destroyed.

"Besides, the ashes of fresh wood are seldom employed until they have been lixiviated, in which state they are deprived of their caustic principle; those ashes which are most commonly made use of for manure are produced either from wood that has been floated in water, or from turf, or from pit-coal, and contain little or no alkaline salt.

"It appears much more probable that ashes, when laid upon ground, destroy the weeds by a well known effect, namely, by seizing with eagerness that moisture which served to produce those weeds, and which in a superabundant quantity is necessary to their existence and support. Whereas those plants which have a firmer texture and a longer root, which are rendered strong by age and by having withstood the rigour of winter, and which are in fact the plants of which the fields are composed, do not suffer any damage from the application of the ashes; but, on the contrary, by being freed from the superfluous weeds which stifled them, and robbed them of a part of their sustenance, they receive a quantity of nourishment proportioned to their wants. The state of relaxation and languor to which they were reduced by a superabundance of water, leaves them, the soil gets its proper consistence, and the grass, corn, &c. acquiring the strength and vigour which is natural to them, soon overcome the moss, rushes, and other weeds; thus a good crop, of whatever the field consists of, is produced. It is in the above manner that wood ashes act, whenever in the spring it is necessary to apply them to meadows, corn fields, &c. the plants of which are stifled and weakened by a luxuriant vegetation of weeds, the usual consequence of mild and wet winters.

"When wood ashes produce an effect different from what is above described, it is either because they happen to contain too much alkaline salt, or that they are laid on the ground in too great quantity, or that the fields to which they are applied were not sufficiently wet to restrain their action; for when they are scattered upon cold soils, and buried by the plough before the time of sowing, they are, like lime, of great service. The last-mentioned substance is very efficacious in other circumstances; and there is a well-known method of using it, practised by the Germans, as follows: A heap of lime is formed by the side of a heap of poor earth, and water is poured upon the lime; the earth is then thrown over it, and becomes impregnated with the vapours which escape from the lime while it is slaked. The earth, after being thus aerated, may be separated; and although no lime remains mixed with it, is, by the operation just described, rendered capable of giving a luxuriant vegetation to whatever plants may be put into it.

"It is possible, therefore, to aerate earth as well as fluids; for this purpose, by mixing it with certain substances, during their decomposition, we must attach to it the principles of which those substances are composed; from which there results a matter so loaded with gas, as to form a more compound substance, and one which has acquired new properties. The Arabians, for example, who take great pains to improve their land, are accustomed to make large pits, which they fill with animals which happen to die: these pits they afterwards cover with calcareous or clayey earth; and after some time these earths, which of themselves are sterile, acquire the properties of the richest manures.

"The foregoing observations may at least be considered as proving, that those substances which, when employed fresh and in too great quantity, are most prejudicial to vegetation, have, on the contrary, an advantageous effect, when they are previously made to undergo a fermentation; or when they are mixed with earth or water, in a proportion adapted to the end proposed. The grass of fields in which cattle or poultry go to feed, after the first or second crop of hay, appears to be dried by the urine and dung of those animals; as if fire had been applied to it; whereas these same excrementitious substances, when combined with earth, or diluted with water, are capable, without any other preparation, of performing the office of good manure.

"But if animal secretions, when applied in substance to plants, were capable of acting upon them, as is affirmed, in such a way as to corrode or burn them, how could seed which has been swallowed, and escaped the action of the digestive powers, be prolific when thrown out by the animal, after having remained so long in its dung? yet we often see oats, so circumstanced, grow and produce seed. Is it not more consistent with experience and observation to suppose, that these excrementitious substances, being still endowed with animal heat, and with an organic motion, diffuse round plants in vegetation a deleterious principle or inflammable gas, which destroys them; for soon after their application, the foliage of the plant grows yellow, dries up, and the plant withers, unless there happens a shower of rain

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which revives it. When theſe ſubſtances are diluted, by being mixed with water and earth, they loſe that principle which is ſo deſtructive to vegetable life, and an incipient fermentation augments their power as a manure, ſo that they may be immediately made uſe of without any apprehenſion of injury from their effects.

mit a greater fault, than to put more than a certain quantity of them into the water he means to make uſe of to water his young plants; in ſhort, this kind of manure is to be uſed in a very ſparing manner; and he that is too prodigal of it will find, to his coſt, that exceſs, even of that which is otherwiſe beneficial, becomes an evil.

"It muſt certainly be allowed, that excrementitious ſubſtances are a very advantageous manure for cold ſoils, and ſuited to moſt vegetable productions; a long experience of their effects over a large tract of country, and the acknowledged intelligence of the Flemiſh farmers, ought to be conſidered as ſufficient to overcome the prejudice that has been raiſed againſt this ſort of manure. Suppoſing that the bad effects which have been attributed to it, when uſed in the ſtate in which it is taken out of privies, &c. are not the offspring of a prejudiced imagination, they may have ariſen from its having been made uſe of at an improper time, or in too great quantity; or from its having been applied to a ſoil and for the cultivation of plants to which it was not adapted; for we know that the exceſs of any kind of manure changes the ſmell and taſte of plants, and the ſame effect is produced by watering them too frequently. Striking examples of this change are ſeen in the ſtrawberry and in the violet, when ſuch as have grown in the woods are compared to thoſe produced from ſome of our over-manured gardens; alſo in the lettuce, and ſome other plants, when thoſe raiſed for ſale by the gardeners about Paris are compared to thoſe of ſome particular kitchen gardens. In the markets of ſome cities, the carrots, turnips, and potatoes of the fields, are preferred to the ſame kind of roots cultivated by the gardeners (A); for though the laſt are of a larger ſize, they have not ſo good a flavour. Some vegetables, therefore, are like certain wild ſpecies of the animal kingdom; they reſiſt every kind of culture, as thoſe animals reſiſt every effort to tame them.

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"Although experience has taught the Flemiſh farmers, that excrementitious ſubſtances are more active in their natural ſtate than when dried, yet it cannot be denied that drying them, and reducing them into powder, is ſometimes very advantageous, becauſe in that ſtate they are much leſs offenſive, are eaſily tranſported to any diſtance, and may be uſed when moſt convenient or moſt proper. In many cities the inhabitants pay to have their privies emptied: in other places, thoſe who empty them pay for their contents; and it would aſtoniſh any one to be told how great a revenue is produced in the city of Liſle in Flanders by the ſale of this kind of manure. I am, however (ſays our author), far from thinking that it is right, in all caſes, to employ it in the above mentioned ſtate of concentration; it would be better, in my opinion, to follow the example of the Flemiſh farmers, who uſe it the firſt year for the cultivation of plants for oil, or for hemp or flax; and the ſecond year for the beſt kinds of grain: thus obtaining two crops, inſtead of one, without any farther preparation of the land. What is ſaid above may be applied alſo to the manures produced from the dung of cattle, poultry, &c. (particularly to pigeons dung, the moſt powerful manure of its kind), all which, by being dried and powdered before they are uſed, loſe a great portion of their activity. From theſe obſervations another fact may be deduced, namely, that manure ſhould not be taken from the place where it has been thrown together until the ſeaſon of the year and the ſtate of the land are ſuch that it may be put into the ground as ſoon as it is brought to it. In ſome diſtricts a very injurious cuſtom prevails of carrying the manure into the fields, and leaving it there formed into ſmall heaps, expoſed for ſome days to the elements; during which time, either the ſun and wind dry up its natural moiſture, leaving a maſs which is much leſs active; or the rain diſſolves and carries away the extractive part impregnated with the ſalt. This kind of brine, which is the moſt powerful part of the manure, penetrates the earth to a conſiderable depth, and ſhews (by the thick tufts which ariſe in thoſe places, and which produce more ſtraw than grain) that manure ought to be put into the ground as ſoon as it is brought to it, becauſe it then poſſeſſes its full force and effect, and conſequently would be then uſed to the greateſt advantage.

"We have always at hand the means of compoſing, from a great variety of vegetable and animal ſubſtances, ſuch manures as, when brought into a proper ſtate, and mixed with land, contribute to its fertility. Chemiſtry alſo offers to us a number of ſubſtances, which, although when uſed ſeparately they tend to diminiſh the fertiliſing quality of the earth, are yet capable, by being combined, of forming excellent manures; ſuch, for inſtance, is that ſaponaceous combination which is produced from a mixture of potaſh, oil, and earth. What an advantage it would be, if, inſtead of being ſparing of manure, the inhabitants of the country would endeavour to increaſe the number of theſe reſources, and to render them more beneficial, by employing them in a more

(A) We believe they are univerſally preferable.

Mason. the year 1779, when the city of London and some other commercial towns, agreed to present their petitions to parliament for a more economical expenditure of the public money, and a more equal representation of the people, Mr Mason came forward, and took an active part in promoting these designs, as one who was convinced of their importance and necessity. When the county of York assembled, on the 30th of December 1779, and resolved unanimously, "that a committee of correspondence should be appointed, for the effectually promoting the object of the petition then agreed to, and also to prepare a plan of *association* to support that laudable reform, and such other measures as may conduce to restore the *freedom of parliament*," he was chosen upon the committee, and was consulted with, or assisted in drawing up those various high-spirited resolutions and addresses to the public, for which the Yorkshire committee was so celebrated; and which was afterwards generally adopted by the other associated bodies of reformers. This part of his conduct is surely entitled to no praise. Thinking as we do of the parliamentary reformers, we cannot but regret that a man of Mr Mason's talents and virtues should have embarked in their dangerous pursuits; and though we perceived less hazard in those pursuits than we do, we should still consider them as unsuitable to the character of a clergyman. Our author, however, was of a different opinion. In reply to a censure passed by a dignified clergyman on the political conduct of himself and some of his reverend brethren, he published, without his name indeed, a spirited defence of their proceedings and designs in some of the country papers. The York committee, too, at its next meeting, resolved, "that a Protestant, by entering into holy orders, does not abandon his civil rights;" they also resolved, "that the thanks of the committee be given to those reverend gentlemen who, thus preferring the public good to their own private emoluments, have stood forth the firm friends to the true interests of their country."

Mr Mason, however, showed, by his subsequent conduct, that however earnestly he might wish for what he doubtless considered as an expedient reform in the commons-house of Parliament, he was firmly attached to the British constitution He was indeed a whig; but he was a whig of the old school. In the beginning of 1794, when the reformers had betrayed the principles of French democrates, he deserted them, and ranged himself under the banners of the servants of the crown; and for this conduct, which was certainly consistent, he has been plentifully traduced by our Jacobin journalists as an alarmist, who not only deserted his old friends, but ascribed to them a certain degree of guilt and political depravity.

The death of this great and good man, which happened in April 1797, was occasioned neither by age nor by inveterate disease. As he was stepping into his chariot, his foot slipped, and his shin grazed against the step. This accident had taken place several days before he paid the proper attention to it; and on April the 3d a mortification ensued, which, in the space of forty-eight hours, put a period to his life.

That he was a scholar and a poet of high eminence is universally acknowledged; and we are assured, that his posthumous works, when published, will not detract from his living fame. In private life, though he affect-perhaps too much the fastidious manners of Mr Gray, whose genius he estimated with a degree of enthusiasm amounting almost to idolatry, his character was distinguished by philanthropy and the most fervid friendships; and he may be considered as a man who merits to be ranked with the ablest supporters of British liberty and British morals.

Masonry. FREE MASONRY, is a subject which, after the copious detail given in the *Encyclopædia* of its lodges, and wardens, and grand masters, we should not have resumed in this place, but to warn our countrymen against the pernicious superstructures which have been raised by the French and Germans on the simple system of British masonry.

Much falsehood is current respecting the origin and antiquity of the masonic associations. That the Dionysiacs of Asia Minor were a society of architects and engineers, who had the exclusive privilege of building temples, stadia, and theatres, under the mysterious tutelage of Bacchus, seems to be unquestionable. "We are also certain, that there was a similar trading association during the dark ages in Christian Europe, which monopolized the building of great churches and castles, and enjoyed many privileges under the patronage of the various sovereigns. Circumstances (says Dr Robison), which it would be tedious to enumerate and discuss, continued this association longer in Britain than on the continent;" but there is no good evidence, that, anterior to the year 1648, any man sought admission into it, who was not either a builder by profession, or at least skilled in the science of architecture. At that period, indeed, Mr Ashmole, the famous antiquary (see ASHMOLE, *Encycl.*), was admitted into a lodge at Warrington, together with his father-in-law Colonel Mainwaring; and these are the first distinct and unequivocal instances that we have in Britain of men unconnected with the operative masons being received into their mysterious fraternity. The secrecy, however, of the lodges, made them fit places for the meetings of the royalists; and accordingly many royalists became free masons. "Nay, the ritual of the master's degree seems to have been formed, or perhaps twisted from its original institution, so as to give an opportunity of sounding the political principles of the candidate, and of the whole brethren present. For it bears so easy an adaptation to the death of the king, to the overturning of the venerable constitution of the English government of three orders by a mean democracy, and its re-establishment by the efforts of the loyalists, that this would start into every person's mind during the ceremonial, and could hardly fail to shew, by the countenances and behaviour of the brethren, how they were affected."

This supposition receives much countenance from the well known fact, that "Charles II. was made a mason, and frequented the lodges. It is not unlikely, that besides the amusement of a vacant hour, which was always agreeable to him, he had pleasure in meeting with his loyal friends, and in the occupations of the lodge, which recalled to his mind their attachment and services. His brother and successor James II. was of a more serious and manly cast of mind, and had little pleasure in the frivolous ceremonies of masonry. He did not frequent the lodges. But, by this time, they were the resort of many persons who were not of the profession, or members of the trading corporation. This circum-

stance,

Masonry. ſtance, in all probability, produced the denominations of *free* and *accepted* maſons. A perſon who has the privilege of working at any incorporated trade, is ſaid to be a *freeman* of that trade. Others were *accepted* as brethren, and admitted to a kind of honorary freedom; as is the caſe in many other trades and incorporations, without having (as far as we can learn for certain) a legal title to earn a livelihood by the exerciſe of it."

It was not till ſome years after this period that the lodges made open profeſſion of the cultivation of general benevolence, and that the grand aim of the fraternity was to enforce the exerciſe of all the ſocial virtues. The eſtabliſhment of a fund for the relief of unfortunate brethren did not take place till the very end of the laſt century; and we may preſume, that it was brought about by the warm recommendations of ſome benevolent members, who would naturally enforce it by addreſſes to their aſſembled brethren. Hence the probable origin of thoſe philanthropic diſcourſes, which are occaſionally delivered in the lodges by one of the brethren as an official taſk.

The boaſted philanthropy of maſons ſerves, however, another purpoſe. The inquiſitive are always prying and teazing, eager to diſcover the ſecrets of their neighbours; and hence the brethren are induced to ſay, that univerſal beneficence is the great aim of the order, for it is the only point on which they are at liberty to ſpeak. They forget, that univerſal beneficence and philanthropy are inconſiſtent with the excluſive and monopolizing ſpirit of an aſſociation, which not only confines its benevolence to its own members (like any other charitable aſſociation), but hoards up in its boſom ineſtimable ſecrets, whoſe natural tendency, they ſay, is to form the heart to this generous and kind conduct, and inſpire us with love to all mankind. The profane world cannot ſee the beneficence of concealing from public view a principle or a motive which ſo powerfully induces a maſon to be good and kind. The brother ſays, that publicity would rob it of its force; and we muſt take him at his word; and our curioſity is ſo much the more excited, to learn what are the ſecrets which have ſo ſingular a quality; for they muſt be totally unlike the principles of ſcience, which produce their effects only when made public.

From this account of maſonry, it would appear to have been at firſt a loyal aſſociation, and as ſuch it was carried over from England to the continent; for all the maſons abroad profeſs to have received their myſteries from Great Britain. It was firſt tranſported into France by the zealous adherents of King James, who, together with their unfortunate maſter, took refuge in that country; and it was cultivated by the French in a manner ſuited to the taſte and habits of that highly poliſhed and frivolous people. To the three ſimple Britiſh degrees of *apprentice*, *fellow-craft*, and *maſter*, they gradually added degrees innumerable, all decorated with ſtars and ribbons; and into their lodges they introduced the impieties and ſeditious doctrines of Voltaire and the other philoſophiſts. Indeed, if the account which the Abbé Barruel gives of maſonry be juſt, it muſt be admitted, that even the ſecrets of the moſt ancient lodges, though in one ſenſe harmleſs and juſt, are ſo expreſſed, that they may be eaſily twiſted to very dangerous purpoſes. This author was advanced by a few friends to the degree of maſter, without being obliged to take the oath of ſecrecy and being furniſhed with the ſigns, he got admiſſion into a lodge, where he heard the ſecret regularly communicated, with all the ordinary forms, to an apprentice. "It would be uſeleſs, ſays he, to deſcribe the ceremonials and trials on ſuch occaſions; for in the firſt degrees, they are nothing more than the play of children. The grand object was the communication of the famous ſecret, when the candidate was ordered to approach nearer to the venerable. At that moment, the brethren, who had been armed with ſwords for the occaſion, drawing up in two lines, held their ſwords elevated, leaning the points towards each other, and formed what in maſonry is called the *arch of ſteel*. The candidate paſſed under this arch to a ſort of altar elevated on two ſteps, at the fartheſt end of the lodge. The maſter, ſeated in an arm chair, or a ſort of throne, behind this altar, pronounced a long diſcourſe on the inviolability of the ſecret which was to be imparted, and on the danger of breaking the oath which the candidate was going to take. He pointed to the naked ſwords, which were always ready to pierce the breaſt of the traitor; and declared to him that it was impoſſible to eſcape their vengeance. The candidate then ſwore, "that rather than betray the ſecret, he contented to have his head cut off, his heart and entrails torn out, and his aſhes caſt before the winds." Having taken the oath, the maſter ſaid the following words to him: "My dear brother, the ſecret of maſonry conſiſts in theſe words, EQUALITY AND LIBERTY; *all men are equal and free; all men are brethren.*" The maſter did not utter another ſyllable, and every body embraced the new *brother equal and free*. The lodge broke up, and we gayly adjourned to a maſonic repaſt."

In the Britiſh lodges, the author admits, that no other interpretation is given to this famous ſecret, than that, as all men are children of one common parent, and creatures of the ſame God, they are in duty bound to love and help each other as brethren; but he contends, that in France it was differently interpreted; and he ſupports his opinion by the following arguments:

On the 12th of Auguſt 1792, Louis XVI. was carried a priſoner to the tower of the *temple*, ſo called becauſe it formerly belonged to the knights templars. On that day, the rebel aſſembly decreed, that to the date of *liberty* the date of *equality* ſhould be added in future in all public acts; and the decree itſelf was dated the fourth year of *liberty*, the firſt year and firſt day of *equality*. It was on that day, for the firſt time, that the ſecret of free-maſonry was made public; that ſecret ſo dear to them, and which they preſerved with all the ſolemnity of the moſt inviolable oath. At the reading of this famous decree, they exclaimed, "We have at length ſucceeded, and France is no other than an immenſe lodge. The whole French people are free maſons, and the whole univerſe will ſoon follow their example."

"I witneſſed (ſays our author) this enthuſiaſm; I heard the converſations to which it gave riſe; I ſaw maſons, till then the moſt reſerved, who freely and openly declared, 'Yes, at length the grand object of free-maſonry is accompliſhed, EQUALITY and LIBERTY; *all men are equal and brothers; all men are free.* That was the whole ſubſtance of our doctrine, the object of our wiſhes, *the whole of our grand ſecret!*'"

This is a very ſerious charge againſt the original ſociet

Masonry. cret of masonry, as it was understood in France; and though the author does not bring it directly against the same secret as understood in Britain, he yet seems to say, that in all lodges, the following question is put to the candidate before he is entrusted with any secret:—"Brother, are you disposed to execute all the orders of the grand-master, though you were to receive contrary orders from a king, an emperor, or any other sovereign whatever?" And as the brother is obliged to promise this unlimited obedience, it is easy to conceive how much a traiterous conspiracy may be promoted by means of mason lodges. The allegorical story which is told at the conferring of the degree of master, is capable of various and even contrary interpretations; for though in this country it was originally rendered subservient to the purposes of the royalists, in the occult lodges on the continent it has been made the vehicle of treason and impiety.

When the degree of master-mason is to be conferred, the lodge is hung round with black. In the middle is a coffin covered with a pall, the brethren standing round it in attitudes denoting sorrow and revenge. When the new adept is admitted, the master relates to him the following history or fable:

"Adoniram presided over the payment of the workmen who were building the temple by Solomon's orders. They were three thousand workmen. That each one might receive his due, Adoniram divided them into three classes, apprentices, fellow crafts, and masters. He entrusted each class with a word, signs, and a gripe, by which they might be recognised. Each class was to preserve the greatest secrecy as to these signs and words. Three of the fellow-crafts, wishing to know the word, and by that means obtain the salary, of master, hid themselves in the temple, and each posted himself at a different gate. At the usual time when Adoniram came to shut the gates of the temple, the first of the three met him, and demanded the *word of the masters;* Adoniram refused to give it, and received a violent blow with a stick on his head. He flies to another gate, is met, challenged, and treated in a similar manner by the second: flying to the third door, he is killed by the fellow-craft posted there, on his refusing to betray the word. His assassins buried him under a heap of rubbish, and marked the spot with a branch of acacia.

"Adoniram's absence gave great uneasiness to Solomon and the masters. He is sought for every where: at length one of the masters discovers the corpse, and, taking it by the finger, the finger parted from the hand; he took it by the wrist, and it parted from the arm; when the master, in astonishment, cried out, *Mac Benac;* which the craft interprets by "*the flesh parts from the bones.*"

"Lest Adoniram should have revealed the *word*, the masters convened and agreed to change it, and to substitute the words *Mac Benac;* sacred words, that free-masons dare not pronounce out of the lodges, and there each only pronounces one syllable, leaving his neighbour to pronounce the other."

The history finished, the adept is informed, that the object of the degree he has just received is to recover the word lost by the death of Adoniram, and to revenge this martyr of the masonic secrecy. The generality of masons, looking upon this history as no more than a fable, and the ceremonies as puerile, give themselves very little trouble to search farther into these mysteries.

These sports, however, assume a more serious aspect when we arrive at the degree of elect (*Elu*). This degree is subdivided into two parts; the first has the revenging of Adoniram for its object, the other to recover the *word*, or rather the sacred doctrine which it expressed, and which has been lost.

In this degree of elect, all the brethren appear dressed in black, wearing a breast-piece on the left side, on which is embroidered a death's head, a bone, and poignard, encircled by the motto of *Conquer or die.* The same motto is embroidered on a ribband which they wear in saltier. Every thing breathes death and revenge. The candidate is led into the lodge blindfolded, with bloody gloves on his hands. An adept with a poignard in his hand threatens to run him through the heart for the crime with which he is accused. After various frights, he obtains his life, on condition that he will revenge the father of masonry in the death of his assassin. He is shewn to a dark cavern. He is to penetrate into it; and they call to him, Strike all that shall oppose you; enter, defend yourself, and avenge our master; at that price you shall receive the degree of elect. A poignard in his right hand, a lamp in his left, he proceeds; a phantom opposes his passage; he hears the same voice repeat, Strike, avenge Hiram; there is his assassin. He strikes, and the blood flows.—Strike off his head, the voice repeats; and the head of the corpse is lying at his feet. He seizes it by the hair (A), and triumphantly carries it back as a proof of his victory; shows it to each of the brethren, and is judged worthy, of the new degree.

Our author says, that he has questioned divers masons whether this apprenticeship to ferocity and murder had never given them the idea, that the head to be cut off was that of kings; but they all affirmed that such an idea had never occurred to them till the French revolution had convinced them of the fact. At this indeed we are not surprised. The assassin of Hiram is no where said to have been a king; and why should the young elect have supposed, that when stabbing that assassin, he was training to be a regicide? The ceremony, however, is certainly ferocious in the highest degree, and obviously calculated to reconcile the masons of the occult lodges to the practice of assassination at the command of their superiors; and when it is remembered, that they are bound to pay obedience to those unseen superiors even against their lawful sovereigns, the atrocities of the revolution would naturally make them interpret this shocking ceremony as it is interpreted by the Abbé.

It was the same with respect to the religious part of this degree, where the adept is at once pontiff and sacrificer with the rest of the brethren. Vested in the ornaments of the priesthood, they offer bread and wine, according to the order of Melchisedec. The secret object of this ceremony is to re-establish religious equality, and to exhibit all men equally priests and pontiffs, to recal the brethren to natural religion, and to persuade them that the religion of Moses and of Christ had violated religious equality and liberty by the distinction of

(A) The reader may easily conceive that this corpse is no more than a mannikin containing bladders full of blood.

of priests and laity. It was the revolution again which opened the eyes of many of the adepts, who then owned that they had been dupes to this impiety, as they had been to the regicide essay in the former part.

Our author treats the fraternity of the occult lodges through the higher degrees of Scotch masonry, those of the Rosicrucians, and that of the knights Kadosch; and sums up his account in the following terms:

"In the two first degrees, that is to say, in those of *apprentice* and *fellow-craft*, the sect begins by throwing out its equality and liberty. After that, it occupies the attention of its novices with puerile games of fraternity or masonic repasts; but it already trains its adepts to the profoundest secrecy by the most frightful oaths.

"In that of *master*, it relates the allegorical history of Adoniram, who is to be avenged; and of the *word*, which is to be recovered.

"In the degree of *elect*, it trains the adepts to vengeance, without pointing out the person on whom it is to fall. It carries them back to the time of the patriarchs, when, according to them, men knew no religion but that of nature, and when every body was equally priest and pontiff. But it had not as yet declared that all religion revealed since the time of the patriarchs was to be thrown aside.

"This last mystery is only developed in the Scotch degrees. There the brethren are declared free: The word so long sought for is, Deism; it is the worship of Jehovah, such as was known to the philosophers of nature. The true mason becomes the pontiff of Jehovah; and such is the grand mystery by which he is extricated from that darkness in which the prophane are involved.

"In the degree *Rosæ Crucis*, he who wrested the *word*, who destroyed the worship of Jehovah, is Christ himself, the author of Christianity; and it is on the Gospel and on the Son of Man that the adept is to avenge the brethren, the pontiffs of Jehovah.

"At length, on his reception as Kadosch, he learns that the assassin of Adoniram is the king, who is to be killed to avenge the grand master Molay, and the order of the masons successors of the knights templars. The religion which is to be destroyed to recover the *word*, or the true doctrine, is the religion of Christ, founded on revelation. This word in its full extent is *equality* and *liberty*, to be established by the total overthrow of the altar and the throne.

"Such are the incipient degrees, the process, and the whole system of masonry; it is thus that the sect, by its gradual explanation of its twofold principle of *equality* and *liberty*, of its allegory of the founder of masonry to be avenged, of the word to be recovered, leading the adepts from secret to secret, at length initiates them into the whole Jacobinical code of revolution."

If this account of masonry be not greatly exaggerated, what are we to think of those men among ourselves, who, since the publication of the Abbé Barruel's book and Dr Robison's, have displayed a zeal for the propagation of their mysteries, by which they seemed not to be formerly actuated, and to which the importance of the business that, by their own account, is transacted in the lodges, cannot be thought to bear an adequate proportion? It is not enough to say that British masonry is harmless, and that the *equality* and *liberty* taught in our lodges are the equality and liberty taught in the bible. Without directly questioning this assertion, we only beg leave to put our countrymen in remembrance, that French and German masonry, as it was derived from Britain, must have been originally as harmless as our own; and to call their attention to the monstrous superstructures of impiety and rebellion which in these countries have been raised upon our foundation. Have there been no symptoms of sedition and irreligion among us, since the commencement of the French revolution, that we should be so confident that the equality and liberty of our lodges will never degenerate into the equality and liberty of the French Jacobins? This cannot be said; for it has been proved, that there are several occult lodges in Britain; and what security have we, or what security can we receive, that their number will not increase? The legislature indeed has lately laid some salutary restraints on the meetings of masons; but such is the nature of these meetings, that nothing can effectually secure us against the introduction of the higher mysteries, but the voluntary shutting up for a time of all lodges. This has been done by the honest masons in Germany; and why may it not be done by the masons in Britain? The fund for the relief of poor brethren may surely be managed without secrecy; the signs and gripe may be communicated without the *word*, or exacting a promise of implicit obedience; and the relinquishing of the joys of a social hour would be no great sacrifice to the peace of a country.

But is British masonry really so harmless as the younger masons wish us to believe? The writer of these reflections was never initiated in its mysteries, and therefore cannot, from his own knowledge, say what is their tendency; but he has no hesitation to affirm, because he believes himself able to demonstrate, that it is grossly immoral to promise implicit obedience to unknown superiors, or to swear that one will keep inviolate a secret, to the nature of which he is an absolute stranger. He hopes, indeed, and is inclined to believe, that, in the decent lodges of Britain, the candidate is assured, before he is required to take the oath, that the secret to be communicated, and the obedience which he is to pay, militate in no respect against the civil government or the religion of his country; but still if the secret contain information of value, it is, in his opinion, sinful to keep it a secret; and he cannot conceive upon what principle a native of Britain can promise unlimited obedience to any human being. The mysteries of masonry must relate to something which is either important and laudable; frivolous, though innocent; or dangerous and immoral. To confine to a sect any information which is laudable and important, is surely not to act the part of genuine philanthropists; to administer the most tremendous oaths in the midst of frivolous amusements, is to violate one of the most sacred precepts of our holy religion; and, as no man will pretend to vindicate dangerous and immoral mysteries, masonry appears, in every point in which it can be placed, an association which no good Christian will think himself at liberty to encourage.

MASUAH (See MASSUAH, *Encycl.*) is in latitude 15° 35′ 5″ north, and in longitude 39° 36′ 30″ east of Greenwich. On the 22d of September 1769 Mr Bruce found the variation of the needle at Masuah to be 12° 43′ west.

MATMAI, or MATSUMAI, is the largest of the Kurile islands; and if it be not independent, is tributary

Mayorga, Mayow. to Japan. The capital town of the same name, Matmai, is situated on the sea-shore, on the south-west side. It was built and is inhabited by the Japanese. It is a fortified place, furnished with artillery, and defended by a numerous garrison. The island of Matmai is the place of exile for persons of distinction at Japan: it is separated from that empire by only a narrow channel, but which is considered as dangerous, because the capes, which project on both sides, render the navigation difficult. The people are said to be sensible to friendship, hospitable, generous, and humane.

MAYORGA (Martin de). See *Don Martin*, &c. in this *Suppl.*

MAYOW (John), whose discoveries in chemistry have astonished the scientific part of the public, descended, says Wood, from a genteel family living at *Bree* in the county of *Cornwall*. His father was probably a younger son, bred to business; for our author was born in Fleet-street, London, in the parish of St Dunstan's in the West. At what school he received the rudiments of his education, a circumstance which the biographers of men eminent in the republic of letters should never omit, we have not been able to learn; but on the 27th of September 1661, when he had just completed his 16th year, he was admitted a scholar of Wadham college, Oxford. Some time afterwards, on the recommendation of Henry Coventry, Esq; one of the secretaries of state, he was chosen probationer fellow of All-souls college. As Wood informs us that he had here a *Legist's place*, an expression by which we understand a law-fellowship, it is not wonderful that he took his degrees in the civil law, though physic and the physical sciences were the favourite objects of his study. He was indeed an eminent physician, practising both in London and in Bath, but in the latter city chiefly in the summer months, till the year 1679, when he died, some time during the month of September, in the house of an apothecary in York-street, Covent Garden, and was buried in the church of that parish He had been married, says Wood, a little before his death, not altogether to his content; and indeed he must have been very discontented, if he chose to die in the house of a friend rather than in his own. He published, "Tractatus quinque medico physici, 1. De salnitro; 2. De respiratione; 3. De respiratione fœtus in utero et ovo; 4. De motu musculari et spiritibus animalibus; 5. De Rachitide." These were published together in 8vo at Oxford, in 1674; but there is an edition of two of them, "De respiratione," and "De Rachitide," published together at Leyden in 1671.

The fame of this author has been lately revived and extended by Dr Beddoes, who published, in 1790, "Chemical Experiments and Opinions, extracted from a work published in the last century," 8vo; in which he gives to Mayow the highest credit as a chemist, and ascribes to him some of the greatest modern discoveries respecting air, giving many extracts from the three first of his treatises. His chief discovery was, that oxygen gas, to which he gave the name of *fire air*, exists in the nitrous acid, and in the atmosphere; which he proved by such decisive experiments, as to render it impossible to explain how Boyle and Hales could avoid availing themselves, in their researches into air, of so capital a discovery. Mayow also relates his manner of passing aeriform fluids under water, from vessel to vessel, which is generally believed to be a new art. He did not collect dephlogisticated air in vessels, and transfer it from one jar to another, but he proved its existence by finding substances that would burn in vacuo, and in water when mixed with nitre; and after animals had breathed and died in vessels filled with atmospheric air, or after fire had been extinguished in them, there was a residuum which was the part of the air unfit for respiration, and for supporting fire; and he further shewed that nitrous acid cannot be formed, but by exposing the substances that generate it to the atmosphere. Mayow was undoubtedly no common man, especially since, if the above dates are right, he was only 34 at the time of his death. But he was not so unknown as Dr Beddoes supposed; for since the repetition of the same discovery by Priestley and Scheele, reference has frequently been made by chemists to Mayow as the original inventor; thus allowing to him a species of merit, to which he has perhaps but a doubtful claim, and which, if that claim be well founded, must certainly be shared between him and Dr Hooke. See Hooke in this *Supplement*.

Mean, Measure. MEAN, in general. See *Encycl.*

Arithmetical Mean, is half the sum of the extremes. So 4 is an arithmetical mean between 2 and 6, or between 3 and 5, or between 1 and 7; also an arithmetical mean between a and b is $\frac{a+b}{2}$, or $\frac{1}{2}a+\frac{1}{2}b$.

Geometrical Mean, commonly called a mean proportional, is the square root of the product of the two extremes; so that, to find a mean proportional between two given extremes, multiply these together, and extract the square root of the product. Thus, a mean proportional between 1 and 9, is $\sqrt{1\times 9}=\sqrt{9}=3$; a mean between 2 and $4\frac{1}{2}$ is $\sqrt{2\times 4\frac{1}{2}}=\sqrt{9}=3$ also; the mean between 4 and 6 is $\sqrt{4\times 6}=\sqrt{24}$; and the mean between a and b is $\sqrt{ab}$.

Harmonical Mean. See *Harmonical Proportion*, Encycl.

Mean and Extreme Proportion, or *Extreme and Mean Proportion*, is when a line or any quantity is so divided that the less part is to the greater, as the greater is to the whole.

Mean Anomaly of a Planet, is an angle which is always proportional to the time of the planet's motion from the aphelion or perihelion, or proportional to the area described by the radius vector; that is, as the whole periodic time in one revolution of the planet, is to the time past the aphelion or perihelion, so is 360° to the mean anomaly. See Anamoly, *Encycl.*

Mean Conjunction or *Opposition*, is when the mean place of the sun is in conjunction, or opposition, with the mean place of the moon in the ecliptic.

Mean Distance of a Planet from the Sun, is an arithmetical mean between the planet's greatest and least distances.

Mean Motion, is that by which a planet is supposed to move equably in its orbit; and it is always proportional to the time.

Mean Time, or *Equal Time*, is that which is measured by an equable motion, as a clock; as distinguished from apparent time, arising from the unequal motion of the earth or sun.

Universal or Perpetual MEASURE, is a kind of

Units. of measure unalterable by time or place, to which the measures of different ages and nations might be reduced, and by which they may be compared and estimated. Such a measure would be very useful if it could be attained; since, being used at all times, and in all places, a great deal of confusion and error would be avoided.

It has been attempted, at different times and in different countries, more especially by the French, who, since the commencement of their revolutionary government, have laboured hard to obtrude their innovations in arts and science, as well as in politics, upon all nations. Proposals, however, have been made by soberer men for a standard both of weights and of measures for all nations; and some of the most rational of these shall be noticed under the word WEIGHTS in this *Supplement*.

MECHANICS.—Our readers will recollect that in the article PHYSICS, *Encycl.* we proposed to distinguish by the term *Mechanical Philosophy* that part of natural science which treats of the local motions of bodies, and the causes of those phenomena. And, although all the changes which we observe in material nature are accompanied by local motion, and, when completely explained, are the effects (perhaps very remote) of those powers of matter which we call *moving forces*, and of those alone, yet, in many cases, this local motion is not observed, and we only perceive certain ultimate results of those changes of place. This is the case (for example) in the solution of a grain of silver in a phial of aquafortis. In the beginning of the experiment, the particles of silver are contained in a small space at the bottom of the phial; but they are finally raised from the bottom, and uniformly disseminated over the whole fluid. If we fix our attention steadily on one particle, and trace it in its whole progress, we contemplate nothing but a particle of matter acted on by moving forces, and yielding to their action. Could we state, for every situation of the particle, the direction and intensity of the moving force by which it is impelled, we could construct a figure, or a formula, which would tell us the precise direction and velocity with which it changes its place, and we could delineate its path, and tell the time when it will arrive at that part of the vessel where it finally rests in perfect equilibrium. Newton having done all this in the case of bodies acted on by the moving force called gravity, has given us a complete system of mechanical astronomy. The philosopher who shall be as fortunate in ascertaining the paths and motions of the particles of silver, till the end of this experiment, will establish a system of the mechanical solution of silver in aquafortis; and the theorems and formulæ which characterise this particular moving force, or this modification of force, stating the laws of variation by a change of distance, will be the complete theory of this chemical fact. It is this modification of moving force which is usually (but most vaguely) called the *chemical affinity*, or the *elective attraction of silver and aquafortis*.

But, alas! we are, as yet, far from having attained this perfection of chemical knowledge. All that we have yet discovered is, that the putting the bit of silver into the spirit of salt will not give occasion to the exertion of this moving force; and we express this observation, by calling that unknown force (unknown, because we are ignorant of the law of its action) an *affinity*, an *elective* attraction. And we have observed many such elections, and have been able to class them, and to tell on what occasions they will or will not be exerted; and this scrap of the complete theory becomes a most valuable acquisition, and the classification of those scraps a most curious, and extensive, and important science. The chemical philosopher has also the pleasure of seeing gradual approaches made by ingenious men to the complete mechanical explanation of these unseen motions and their causes, of which he has arranged the ultimate results. Mechanics.

The ordinary chemist, however, and even many most acute and penetrating enquirers, do not think of all these motions. Familiarly conversant with the results, they consider them as principles, and as topics to reason from. They think a chemical phenomenon sufficiently explained, when they have pointed out the affinity under which it is arranged. Thus they ascribe the propagation of heat to the expansive nature of fire, and imagine that they conceive clearly how the effect is produced. But if a mathematical philosopher should say, "What is this which you call an expansive fluid? Explain to me distinctly, in what manner this property which you call expansiveness operates in producing the propagation of heat."—We imagine that the chemist would find himself put to a stand. He will then, perhaps for the first time, try to form a distinct conception of an expansive fluid, and its manner of operation. He will naturally think of air, and will reflect on the manner in which air actually expands or occupies more room; and he will thus contemplate local motion and mechanical pressure. He will find, too late, that this gives him no assistance; because the phenomena which he has been accustomed to explain by the expansiveness of fluids have no resemblance whatever to what we see result from the actual expansion of air. Experience has made him acquainted with many effects which the air produces during its expansion; but they are of a totally different kind from those which he thought that he had sufficiently explained by the expansiveness of fire. The only resemblance he observes is, that the air and the heat, which were formerly perceived only in a small space, now appear in a much larger space. The mathematician now desires him to tell in what manner he conceives this expansiveness, or this actual expansion of air or gas. The chemist is then obliged to consider the air or gas as consisting of atoms or particles, which must be kept in their present situation by an external force, the most familiar of all to his imagination, namely, pressure; and all pressures are equally fit. Pressure is a moving force, and can only be opposed to such another moving force; therefore expansiveness supposes, that the particles are under the influence of something which would separate them from each other, if it were not opposed by something *perfectly of the same kind*. It cannot be opposed by greenness, nor by loudness, nor by fear, but only by what is competent to the production of motion; and it may be opposed by any *such* natural power; therefore by gravity, or by magnetism, or electricity, or corpuscular attraction, or by an elective attraction. The chemist, being thus led to the contemplation of the phenomenon in its most simple state, can now judge with some distinctness, what is the nature of those powers with which expansiveness can be

Mechanics. be brought to co-operate or combine. And only now will he be able to speculate on the means for explaining the propagation of heat; and he will perceive, that the general laws of motion, and of the action of moving forces (doctrines which we comprehended under the title of DYNAMICS, *Suppl.*), must be resorted to for a *complete* explanation of all chemical phenomena. The same may be said of the phenomena perceived in the growth of vegetables and animals. All of them lead us ultimately to the contemplation of an atom, which is characterised by being susceptible of local motion, and requires for this purpose the agency of what we call a moving force.

We would distinguish this particular OBJECT of our CONTEMPLATION (consisting of two constituent parts, the atom and the force, related, in fact, to each other by constant conjunction) by the term MECHANISM. We conceive it to be the characteristic of what we call MATTER; and we would consider it as the most simple MECHANICAL PHENOMENON. We are disposed to think, that this moving force is as simple and uniform as the atom to which it is related; and we would ascribe the inconceivable diversity of the moving forces which we see around us to combinations of this universal force exerted by many atoms at once; and therefore modified by this combination, in the very same manner as we frequently see those seemingly different moving forces combine their influence on a sensible mass of tangible matter, giving it a sensible local motion. Having formed such notions, we would say that we do not conceive either the atom or the force as being matter, but the two thus related. And we would then say, that whatever object of contemplation does not ultimately lead us to this complex notion is IMMATERIAL; meaning by the epithet nothing more than the negation of this particular character of the object. It is equivalent to saying, that the phenomenon does not lead the mind to the consideration of an atom actuated by a moving force; that is, moved, or prevented from moving, by an opposite pressure or force.

Such is the extension which the discoveries of last century have enabled us to give to the use of the term mechanism, mechanical action, mechanical cause, &c.

The Greeks, from whom we have borrowed the term, gave it a much more limited meaning; confining it to those motions which are produced by the intervention of machines. Even many of the naturalists of the present day limit the term to those motions which are the *immediate* consequences of impulse, and which are cases of sensible motion. Thus the chemist says, that printers ink is a mechanical fluid, but that ink for writing is a chemical fluid. We make no objection to the distinction, because chemistry is really a vast body of real and important science, although we have, as yet, been able to class only very complicated phenomena, and are far from the knowledge of its elements. This distinction made by the chemists is very clear, and very proper to be kept in view; but we should be at a loss for a term to express the analogy which is perceivable between these sensible motions and the hidden motions which obtain even in the chemical phenomena, unless we give mechanism a still greater extension than the effects of percussion or impulsion.

Mechanics, in the ancient sense of the word, considers only the energy of *organa*, machines. The authors who have treated the subject systematically, have observed, that all machines derive their efficacy from a few simple forms and dispositions, which may be given to that piece of matter called the *tool*, Ὄργανον or *machine*, which is interposed between the workman or natural agent, and the task to be performed, which is always something to be moved, in opposition to resisting pressures. To those simple forms they have given the name of MECHANICAL POWERS, simple powers, simple machines.

The machine is interposed for various reasons.

1. In order to enable a natural power, having a certain determinate intensity, which cannot be increased, to balance or overcome another natural power, acting with a greater intensity. For this purpose, a piece of solid matter is interposed, connected in such a manner with firm supports, that the pressure exerted on the impelled point by the power occasions the excitement of a pressure at the working point, which is equal or superior to the resistance, arising from the work, to the motion of that point. Thus, if a rod three feet long be supported at one foot from the end to which the resistance of two pounds is applied, and if a pressure of one pound be applied to the other end of the rod, perpendicular to its length, the cohesive forces which connect the particles of the rod will all be excited, in certain proportions, according to their situation, and the supported point will be made to press on its support as much as three pounds would press on it; and a pressure in the opposite direction will be excited at the working point, equal to the pressure of two pounds. The resistance will therefore be balanced, and it will be overcome by increasing the natural power acting on the long division of the rod. This is called a LEVER. Toothed wheels and pinions are a perpetual succession of levers in one machine or mechanical power.

2. The natural power may act with a certain velocity which cannot be changed, and the work requires to be performed with a greater velocity. A machine is interposed, moveable round a fixed support, and the distances of the impelled and working points are taken in the proportion of the two velocities. Then are we certain, that when the power acts with its natural velocity, the working point is moving with the velocity we desire.

3. The power may act only in one unchangeable direction, and the resistance must be overcome in another direction. As when a quantity of coals must be brought from the bottom of a pit, and we have no power at command but the weight of a quantity of water. We let the water pull down one end of a lever, either immediately or by a rope, and we hang the coals on the other end, while the middle point is firmly supported. This lever may be made perpetual, by lapping the ropes round a cylinder which turns round an axis firmly supported. This is a FIXED PULLEY. We can set unequal powers in opposition, by lapping each rope round a different cylinder, having the same axis. This is a WINDLASS or GIN. All these forms derive their energy from the lever virtually contained in them.

Any of these three purposes may be gained by the interposition of a solid body in another way. Instead of being supported in one point, round which it is moveable, it may be supported by a solid path, along which it is impelled, and by its shape it thrusts the resisting body

body out of its way. This is the case with the WEDGE when it is employed to force up a swagging joist, or press things strongly together. If this wedge be lapped or formed round an axis, it becomes a SCREW or a SPIRAL WIPER. This is also the operation of the balance wheel of a horizontal or cylinder watch. The oblique face of the tooth is a wedge, which thrusts the edge of the cylinder out of its way. The pallet of a clock or watch is also a wedge, acted on in the opposite direction.

These are the different forms in which a solid body is interposed as a mechanic power. All are reducible to the lever and the wedge.

But there are other mechanic powers besides those now mentioned. The carmen have a way of lowering a cask of liquor into a cellar, by passing a rope under it, making the end fast to some stake close to the ground, and bringing the other end of the rope round the cask, and thus letting it slip down in the bight of the rope. In this process they feel but half of its weight, the other half being supported by the end of the rope that is fastened to the stake. This is called a PARBUCKLE by the seamen. A hanging pulley is quite the same with this more artless method. The weight hangs by the axis of the pulley, and each half of the hanging rope carries half of the weight, and the person who pulls one of them upwards acts only against half of the weight; the other being carried by the hook to which the standing rope is fastened. This mechanical power does not (as is commonly imagined) derive its efficacy from the pulley's turning round an axis. If it were made fast, or if the tackle rope merely passed through a loop of the rope which carries the weight, it would still require only half of the weight acting on the running rope to balance it. The use of the motion round an axis is merely to avoid a very great friction. When the two hanging parts of the rope are not parallel, but inclined in any angle, the force necessary for balancing the weight is to the weight as the side is to the diagonal of the parallelogram formed by the directions of the three ropes. Varignon calls this the FUNICULAR MACHINE or power. Our sailors call it the SWIGG.

We may employ the *quaqua versum* pressure of fluidity with great effect as a mechanic power. Thus, in the hydrostatic bellows described by Gravesande, § 1451, and by Desaguiliers, the weight of a few ounces of water is made to raise several hundred pounds. In like manner, Dr Wallis of Oxford, by blowing with a pipe into a bladder, raised 64 pounds lying on it. Otto Guericke of Magdeburgh made a child balance, and even overcome, the pull exerted by the emperor's six coach horses, by merely sucking the air from below a piston. Mr Bramah, ironmonger in Piccadilly, London, has lately obtained a patent for a machine acting on this principle as a press*. A piston of one-fourth of an inch in diameter, forces water into a cylinder of 12 inches diameter, and by this intervention raises the piston of the cylinder. A boy, acting with the fourth part of his strength on the small piston by means of a lever, raises 42 tons, or 94,080 libs, pressing on the great piston. It is very surprising, that this application of the *quaqua versum* pressure of fluids has been overlooked for more than a century, although the principle has been inculcated and lectured on by every itinerant teacher, and illustrated by the above mentioned experiments of Gravesande and Wallis; nay, it has been expressly taught as a mechanic power of great efficacy by the Professor of Natural Philosophy at Edinburgh every session of the college for these twenty years past, but he never thought of putting it in practice. It forms a most compendious machine of prodigious power, and is susceptible of the greatest strength. If the same multiplication of power be attempted by toothed wheels, pinions, and racks, it is scarcely possible to give strength enough to the teeth of the racks, and the machine becomes very cumbersome and of great expence. But Mr Bramah's machine may be made abundantly strong in very small compass. It only requires very accurate execution. We give it all praise; but Mr Bramah is mistaken when he publishes it as the invention or discovery of a new mechanic power: for it has been familiar to every student of mechanics and hydrostatics ever since Boyle's first publication of his hydrostatic paradoxes.

MEDICAL JURISPRUDENCE. See *MEDICINA Forensis* in this *Suppl.*

MEDICI, is the name of an illustrious family in Florence, which contributed more than perhaps any other family whatever to the revival of letters in Europe. To trace this family from its origin, or even to give biographical sketches of all the great men whom it produced, would occupy by far too great a part of our work; for, during some centuries, almost every individual of the house of Medici was distinguished among his contemporaries. That house, after having rendered itself memorable in the annals of Florence, for opposing the encroachments of the nobles on the liberties of the people, had lost much of its influence under the aristocratic government of the Albizi, when it was raised to a rank superior to what it had ever held, by

Giovanni de MEDICI, who was born in the year 1360. This man determined to restore his family to splendour; but, conscious of his critical situation, surrounded as he was by powerful rivals and enemies, he affected rather a secure privacy than a dangerous popularity. Even when raised to the office of gonfalonier, or generalissimo of the republic, he carefully avoided any desire of partaking in the magistracy, and seemed to be entirely engrossed by merchandize, which he extended from the East throughout Europe. This conduct, as on one hand it threw his enemies off their guard, on the other, enabled him to acquire an immense fortune, of which he made a proper disposition amongst all ranks of people.

Many, even of the ruling party, either gained by his liberality, or pleased with his amiable and retired conduct, proposed to the seigniory to admit him into the magistracy; and though the proposal met with great opposition, it was carried in the affirmative.

It was by rashly declaring for the plebeians against the nobles that an ancestor of Giovanni's had lost to his family their rank in the state. Giovanni, resolving not to split on the same rock, continued to affect privacy and retirement, accepting any office in the state with the utmost appearance of reluctance, and never attending at the Palazzo, unless particularly sent for by the seigniory. Rising by these means in the esteem of the people, his enemies became, of course, unpopular; and having obtained a decided superiority over his opponents, he now ventured to procure, that those taxes which the nobles had exacted with the utmost severity and partiality from the people alone, should be levied

upon

Medici. upon the two first orders, in common with the plebeians; and that a law should be ordained, by which personal property might be taxed.

The nobles seeing, with the deepest concern, their consequence so sensibly wounded, and their power so much diminished, held several consultations in private how they might effect his ruin; but their want of unanimity prevented any thing decisive from being carried into execution. The people, alarmed for the safety of their leader and patron, offered him the sovereignty, which his relations and friends urged him to accept; but this his prudence forbad him to take, as with the title of lord he would have gained also that of tyrant. Thus, by his singular prudence, he died possessed of all the power of the state, with the affectation of being the most disinterested citizen in the commonwealth. His death happened in the year 1428.

Giovanni was graceful in his person, and his affability to all established his character for moderation. His extensive knowledge and pleasantry made his company eagerly sought. As all his actions were placid and serene, he was not in want of that trumpet of sedition, popular declamation, which he never attempted. Much to his honour, his elevation was not procured even by the banishment of a single individual; a circumstance until then unknown in Florence, where every new administration was marked with the ruin of families, and by scaffolds stained with blood.

"The maxims (says Mr Roscoe) which, uniformly pursued, raised the house of Medici to the splendour which it afterwards enjoyed, are to be found in the charge given by this venerable old man, on his deathbed, to his two sons Cosmo and Lorenzo. 'I feel (said he) that I have lived the time prescribed me. I die content, leaving you, my sons, in affluence and in health, and in such a station, that, whilst you follow my example, you may live in your native place honoured and respected. Nothing affords me more pleasure than the reflection, that my conduct has given offence to no one; but that, on the contrary, I have endeavoured to serve all persons to the best of my abilities. I advise you to do the same With respect to the honours of the state, if you would live with security, accept only such as are bestowed on you by the laws, and the favour of your fellow citizens; for it is the exercise of that power which is obtained by violence, and not of that which is voluntarily given, that occasions hatred and contention."

MEDICI (Cosmo de), the eldest son of the preceding, was born in 1389. During the life-time of his father, he had engaged himself deeply, not only in the extensive commerce by which the family had acquired its wealth, but in the weightier matters of government. When Giovanni died he was in the prime of life; and though his complexion was swarthy, he had an agreeable person, was well made, of a proper stature, and in conversation united a happy intermixture of gravity with occasional sallies of pleasantry and repartee. His conduct was uniformly marked by urbanity and kindness to the superior ranks of his fellow-citizens, and by a constant attention to the interests and the wants of the lower class, whom he relieved with unbounded generosity. By these means he acquired numerous and zealous partizans of every denomination; but he rather considered them as pledges for the continuance of the power which he possessed, than as instruments to be employed in extending it to the ruin and subjugation of the state. An interchange of reciprocal good offices was the only tie by which the Florentines and the Medici were bound; and perhaps the long continuance of this connection may be attributed to the very circumstance of its being in the power of either of the parties at any time to have dissolved it. Medici.

But the prudence and moderation of Cosmo could not repress the ambitious designs of those rival families, who wished to possess or to share his authority. In the year 1433, Rinaldo de Albizi, at the head of a powerful party, carried the appointment of the magistracy. At that time Cosmo had withdrawn to his seat in the country, to avoid the disturbances which he saw likely to ensue; but at the request of his friends he returned to Florence, where he was led to expect such a union of parties, as might at least preserve the peace of the city. No sooner did he make his appearance in the palace, where his presence had been requested, on pretence of his being intended to share in the administration of the republic, than he was seized upon by his adversaries, and committed to prison.

The conspirators were divided in their opinions as to the disposal of their prisoner. Most of them inclined to follow the advice of Peruzzi, who recommended taking him off by poison. Cosmo, confined in the Alberzettino, a room in one of the turrets of the Palazzo, could hear this dreadful consultation, which was determining, not in what manner he should be tried, but in what manner he should be put to death; and finding that he was to die by an infusion of poison secretly administered to him, a small portion of bread was the only food which he thought proper to take.

Cosmo lived in this manner four days; and, shut up from all his kindred and friends, he soon expected to be numbered with the dead; but here, as it sometimes happens, he found relief where least expected, from the man who had been engaged to take him off. Malavolta, the keeper of the prison, either from compunction, dissatisfaction, or the youth and misfortunes of the illustrious sufferer, relented; and instead of pursuing any criminal intentions against the life of Cosmo, after upbraiding him with entertaining so unworthy an opinion of him, declared that his fears were entirely groundless. To convince him of this, he sat down, and partook of every thing the prisoner chose to eat of. The expressions of gratitude, together with his most engaging manners, and great promises, entirely won Malavolta, who, to ingratiate himself still farther in the good opinion of Cosmo, invited Fargaccio, the most celebrated wit in Florence, to dine with him the next day, from the idea that his sprightly mirth would contribute to lighten his misfortunes.

In the mean time, his brother Lorenzo, and his cousin Averardo, having raised a considerable body of men in Romagna and other neighbouring districts, and being joined by the commander of the troops of the republic, approached towards Florence to his relief. The apprehension, however, that the life of Cosmo might be endangered, if they should proceed to open violence, induced them to abandon their enterprise. At length Rinaldo and his adherents obtained a decree of the magistracy, by which Cosmo was banished to Padua for ten years, his brother to Venice for five years; and several

Medici. veral of their relations and adherents ſhared the ſame fate.

Coſmo received this determination of his judges with a compoſure that gained him the compaſſion and the admiration of many of his moſt inveterate enemies. He would gladly have left the city purſuant to his ſentence; but he was detained by his enemies till their authority ſhould be eſtabliſhed: and it was not till he thought of bribing the gonfalonier, and another creature of Rinaldo's, that he was privately taken from his confinement, and conducted out of Florence.

Padua, to which he was confined by his ſentence, was in the dominions of Venice; but before he could reach that place, he received a deputation from the ſenate, the purport of which was to condole with him for his misfortunes, and to promiſe him their protection and aſſiſtance in whatever he ſhould deſire. He experienced the treatment of a prince rather than that of an exile. Nor were that wiſe people without good reaſons for ſuch a conduct. Venice had long regarded Florence as her rival in commerce, and hoped, by conferring upon Coſmo the moſt flattering diſtinctions, to prevail upon him to reſide there in future; prudently ſuppoſing, that the manufactories of Florence, and the great commerce the Medici had carried on throughout Italy, and extended far beyond it to the wealthieſt kingdoms in Europe, would become their own by enrolling him amongſt their ſubjects.

The readineſs with which Coſmo had given way to the temporary clamour raiſed againſt him, and the reluctance which he had ſhewn to renew thoſe rencounters which had ſo often deluged the ſtreets of Florence with blood, gained him new friends, even during his exile. The utmoſt exertions of his antagoniſts could not long prevent the choice of ſuch magiſtrates as were known to be attached to the cauſe of the Medici; and no ſooner did they enter on their office, than Coſmo and his brother were recalled, and Rinaldo with his adherents were compelled to quit the city. This event took place about a year after the baniſhment of Coſmo.

The ſubſequent conduct of this great man (for great all allow him to have been) has been painted in different colours by different writers. Mr Noble, after Machiavel, compares his cruelties to his fallen foes with thoſe of Sylla and Octavius to the partizans of Marius and Brutus; whilſt Roſcoe repreſents his conduct as in a high degree amiable and generous. It appears to us evident, from his own words, that he had exerciſed ſome cruelties on his exiled enemies; for when one of them wrote to him, that "the hen was hatching," he replied, "She will have but a bad time of it, ſo far from her neſt." When ſome other exiles acquainted him that "they were not aſleep," he anſwered, "he could eaſily believe that, for he thought he had ſpoiled their ſleeping." At another time, ſome of the citizens remonſtrated with him upon the odiouſneſs of his conduct in baniſhing ſo many perſons; telling him, "the republic would be extremely weakened, and God offended, by the expulſion of ſo many good and pious men as he was ſending into baniſhment." His anſwer was, "It would be better for the republic to be weakened than utterly ruined; that two or three yards of fine cloth made many a one look like a good man; but that ſtates were not to be governed or maintained by counting a ſtring of beads, and mumbling over a few *Pater noſters*."

From this time the life of Coſmo de Medici was an almoſt uninterrupted ſeries of proſperity. His misfortunes had taught him, that the affectation of grandeur is more dangerous in a free ſtate than uſurpation. He adopted, therefore, the dreſs, behaviour, and manners, of a private citizen. His clothes were of the ſame faſhion and materials as the reſt of the Florentines. In the ſtreets he walked alone and unguarded. His table was ſupplied from what his eſtate of Mugello produced, nor had he one ſervant more than was abſolutely neceſſary; thus endeavouring to unite the character of a prince with that of a merchant, and a private perſon in a republic. Medici.

Whilſt he rejected all offices in the magiſtracy, no buſineſs was tranſacted without its being firſt ſettled at Mugello: nor did he contract any alliances but with the ſons and daughters of the citizens of Florence; yet all foreign princes and courts paid his children the reſpect due only to thoſe of ſovereigns; and the family of Coſmo received educations equal to thoſe of the greateſt potentates.

A proper judgment may be formed of his immenſe traffic, and the prodigious advantages accruing from it: For though a private citizen of Florence only, yet he poſſeſſed at one time more money than what was in all the treaſuries of the different ſovereigns in Europe. When Alfonſo king of Naples leagued with the Venetians againſt Florence, Coſmo called in ſuch immenſe debts from thoſe places, as deprived them of reſources for carrying on the war. During the conteſt between the houſes of York and Lancaſter, he furniſhed Edward IV. with a ſum of money ſo great, that it might almoſt be conſidered as the means of ſupporting that monarch on the throne.

In his public and private charities, in the number and grandeur of the edifices he erected, not only in Florence, but in the moſt diſtant parts of the world, and in the foundations which he endowed, he ſeemed to more than vie with majeſty. He ſupplied moſt of the exigencies of the ſtate from his private purſe; and there were few citizens that had not experienced his liberality, and many without the leaſt application, particularly the nobles.

But in nothing did his munificence produce ſo much good to the world, or acquire ſuch honour to himſelf, as when it was exerted for the promotion of ſcience, and the encouragement of learned men; and upon nothing did Coſmo delight ſo much to exert it. The ſtudy of the Greek language had been introduced into Italy towards the latter part of the preceding century; but it had again fallen into neglect. After a ſhort interval, an attempt was made to revive it, by the intervention of Emanuel Chryſoloras, a noble Greek, who taught that language at Florence, and other cities of Italy, about the beginning of the 15th century. His diſciples, who were numerous and reſpectable, kept the flame alive till it received new aid from other learned Greeks, who were driven from Conſtantinople by the dread of the Turks, or by the total overthrow of the Eaſtern Empire. To theſe illuſtrious foreigners, as well as to the learned Italians, who ſhortly became their ſucceſsful rivals, even in the knowledge of their national hiſtory and language, Coſmo afforded the moſt liberal ſupport and protection. The very titles of the works of ancient authors, which were brought to light by his munificence,

Medici. nificence, would extend this article beyond its proper limits. Such, indeed, was the eſtimation in which theſe works were then held in Italy, that a manuſcript of the hiſtory of Livy, ſent by Coſmo de Medici to Alfonſo king of Naples, with whom he was at variance, conciliated the breach between them.

As the natural diſpoſition of Coſmo led him to take an active part in collecting the remains of the ancient Greek and Roman writers, ſo he was enabled by his wealth, and by his extenſive mercantile intercourſe with different parts of Europe and of Aſia, to gratify a paſſion of this kind beyond any other individual. To this end he laid injunctions on all his friends and correſpondents, as well as on the miſſionaries and preachers who travelled into the remoteſt countries, to ſearch for and procure ancient manuſcripts, in every language, and on every ſubject. The ſituation of the Eaſtern Empire, then falling into ruins, afforded him an opportunity of obtaining many ineſtimable works in the Hebrew, Greek, Chaldaic, Arabic, and other eaſtern languages. From theſe beginnings aroſe the celebrated library of the Medici; which, after various viciſſitudes of fortune, and frequent and conſiderable additions, has been preſerved to the preſent times under the name of the *Bibliotheca Mediceo Laurentiana.*

Nor was Coſmo a mere collector of books, he was himſelf, even in old age, a laborious ſtudent. Having been ſtruck with the ſublime ſpeculations of Plato, which he had heard detailed in lectures by a Greek monk, who had come from Conſtantinople to the council of Florence, he determined to found an academy for the cultivation of that philoſophy. For this purpoſe he ſelected Marſilio Ficino, the ſon of his favourite phyſician, and deſtined him, though very young, to be the ſupport of his future eſtabliſhment. The education of Ficino was entirely directed to the Platonic philoſophy; nor were the expectations which Coſmo had formed of him diſappointed. The Florentine academy was ſome years afterwards eſtabliſhed with great credit, and was the firſt inſtitution in Europe for the purſuit of ſcience, detached from the ſcholaſtic method then univerſally adopted. It is true, the fanciful doctrines of Plato are as remote from the purpoſes of life as the ſubtleties of Ariſtotle; but, by dividing the attention of the learned between them, the dogmas of the Stagyrite were deprived of that ſervile reſpect which had ſo long been paid to them, and men learned by degrees to think for themſelves.

The foſtering hand of Coſmo was held out to art as well as to ſcience; and architecture, ſculpture, and painting, all flouriſhed under his powerful protection. The countenance ſhewn by him to theſe arts was not ſuch as their profeſſors generally receive from the great. It was not conceded as a bounty, nor received as a favour, but appeared in the friendſhip and equality that ſubſiſted between the artiſt and his patron; and the ſums of money, which Coſmo expended on pictures, ſtatues, and public buildings, appear almoſt incredible.

Coſmo now approached the period of his mortal exiſtence; but the faculties of his mind remained unimpaired. About twenty days before he died, he ſent for Ficino, and enjoined him to tranſlate from the Greek the treatiſe of Xenocrates on death. Calling into his chamber his wife and his ſon Piero, he entered into narrative of all his public tranſactions; in which he gave a full account of his extenſive mercantile connections, and adverted to the ſtate of his domeſtic concerns. To Piero he recommended a ſtrict attention to the education of his ſons; and requeſted, that his funeral might be conducted with as much privacy as poſſible. He died on the firſt of Auguſt 1464, at the age of 75 years, deeply lamented by a great majority of the citizens of Florence. Their eſteem and gratitude had indeed been fully ſhewn ſome time before, when, by a public decree, he was honoured with the title of *Pater Patriæ*, an appellation which was inſcribed on his tomb; and which, as it was founded, ſays Roſcoe, on real merit, has ever ſince been attached to the name of Coſmo de Medici.

Medici (Lorenzo de), juſtly ſtyled the *magnificent*, was the grandſon of Coſmo, and about 16 years of age when his grandfather died. His father Piero de Medici, though poſſeſſed of more than ordinary talents, as well as of a very conſiderable ſhare of worth, was, from various circumſtances, little qualified to maintain the influence which his family had gained in the republic of Florence. From very early life he had been tortured by the gout; and almoſt uninterrupted pain had made him peeviſh. Such a diſpoſition was not calculated to retain the affections of the giddy Florentines, or to perſuade republicans that they were free, while they ſubmitted to the government of a ſingle individual. All this Coſmo had foreſeen, and had done what wiſdom could do to preſerve to his family that aſcendency in the republic which he had himſelf acquired. He exhorted Piero to beſtow the utmoſt care on the education of his ſons, of whoſe capacity he expreſſed a high opinion; he recommended to him Diotiſalvo Neroni, a man whom he had himſelf raiſed from obſcurity to an eminent rank, as a counſellor, in whoſe wiſdom and fidelity he might place the utmoſt confidence: and to bind the inhabitants of Florence to the houſe of Medici by the ſtrongeſt of all ties, he had diſtributed among them, under the denomination of loans, immenſe ſums, which he knew they would not ſoon be able to repay.

Piero paid the utmoſt deference to the dying injunctions of his father. He had himſelf an ardent love of letters; and under the eye of the venerable Coſmo, he had given his two ſons, Lorenzo and Juliano, the beſt poſſible domeſtic education. In the Greek language, in ethics, and in the principles of the Ariſtotelian philoſophy, Lorenzo, the eldeſt, had the advantage of the precepts of the learned Argyropylus (A), and in thoſe of the Platonic ſect he was ſedulouſly inſtructed by Marſilio Ficino (ſee Ficinus, *Encycl.*); but for his moſt valuable accompliſhments he was not indebted to any preceptor. To complete his education, however, it was judged expedient that he ſhould viſit ſome of the principal courts of Italy; and very ſoon after the death of his grandfather, he repaired to Rome, Bologna, Ferrara, Venice, and Milan, where he gained the eſteem of all whoſe eſteem was of value.

Thus

(A) This man had fled from Conſtantinople, when it was taken by the Turks, to Florence, where he was protected by Coſmo de Medici.

Thus attentive was Piero to the advice of his father with respect to the education of his eldest son; nor was he less attentive to it in the choice of his principal counsellor. He intrusted the whole of his affairs into the hands of Neroni, and gave him Cosmo's accounts to peruse and settle. That ambition, which perhaps had lain lurking in this man's mind, was now called forth, and he basely formed the scheme of ruining the son of his patron, by building upon his misfortunes his own future grandeur. For this purpose, he lamented the absolute necessity there was for an immediate call upon those who were indebted to Piero as Cosmo's representative; telling him, that a delay might subject him to the greatest inconveniences. Piero consented, though with reluctance, to his supposed friend's advice. The result was such as Neroni expected. Those who were friends of the father became enemies of the son; and had not Piero discovered the snare, and desisted from such rigorous proceedings, he might have found, when too late, that in supporting the character of the merchant, he had forgotten that of the statesman; for all the citizens of Florence were his debtors.

Soon after this, an attempt was made to assassinate Piero, by a powerful party which had always been inimical to the house of Medici; but it was defeated by Lorenzo, who displayed on that occasion a sagacity and promptitude of mind which would have done honour to the oldest statesman. A few of the conspirators were declared enemies to the state, and condemned to banishment; but by far the greater part of them were pardoned on the solicitation of Lorenzo, who declared, that "he only knows how to conquer, who knows how to forgive."

In the year 1469 Piero de Medici died; and Lorenzo succeeded to his authority as if it had been a part of his patrimony, being requested by the principal inhabitants of Florence, that he would take upon himself the administration of the republic in the same manner that his grandfather and father had done.

In the month of December 1470, a league was solemnly concluded between the pope, the king of Naples, the duke of Milan, and the Florentines, against Mahomet II. who had vowed not to lay down his arms till he had abolished the religion of Christ, and extirpated all his followers. The pope, however (Paul II.), died on the 26th of July 1471; and Sixtus IV. succeeding to the chair of St Peter, Lorenzo was deputed from Florence to congratulate him on his elevation. Two more opposite characters can hardly be conceived than those of Sixtus and Lorenzo. The former was cruel, treacherous, and sordid; the latter was merciful, candid, and generous. Yet such instances of mutual good will took place between them on this occasion, that Lorenzo, who, under the direction of his agents, had a bank established at Rome, was formally invested with the office of treasurer of the Holy See.

Pisa had been under the dominion of Florence from the year 1406, and it had acquired some celebrity on account of its academy, which had existed almost two centuries. That academy, however, had fallen into decay; and, in the year 1472, the Florentines resolved to restore it to its pristine splendour. Five citizens, of whom Lorenzo de Medici was one, were appointed to superintend the execution of their purpose; but Lorenzo, who was the projector of the plan, undertook the chief management of it; and, in addition to 6000 florins annually granted by the state, expended, in effecting his purpose, a large sum of money from his private fortune. In doing this, he only imitated the example of his father and grandfather; for in the course of 37 years, reckoning from the return of Cosmo from banishment, this illustrious family had expended on works of charity or public utility upwards of 660,000 florins. "Some persons (said Lorenzo) would perhaps be better pleased to have a part of it in their purse; but I conceive that it has been of great advantage to the public, and well laid out, and am therefore perfectly satisfied."

In the year 1474, Lorenzo incurred the displeasure of the pope for opposing some of his encroachments on the petty princes of Italy; and the revenge planned by Sixtus was of such a nature as would have disgraced, we do not say a Christian bishop, but the rudest savage. He began by depriving Lorenzo of the office of treasurer of the Roman See, which he gave to the Pazzi, a Florentine family, who, as well as the Medici, had a public bank at Rome. By this step he secured the interest of the Pazzi, who, it is probable, were to govern Florence under the pope, when Lorenzo and Juliano de Medici should be cut off, and their friends and adherents driven from the republic. The principal agent engaged in the undertaking was Franscesco Salviati archbishop of Pisa, to which rank he had lately been promoted by Sixtus, in opposition to the wishes of the Medici. The other conspirators were Giacopo Salviati, brother to the archbishop; Giacopo Poggio, one of the sons of the celebrated Poggio Bracciolini (see Poggius, *Encycl.*); Barnardo Bandini, a daring libertine, rendered desperate by the consequence of his excesses; Giovanni Battisti Montesicco, who had distinguished himself as general of the pope's armies; Antonio Maffei, a priest of Volterra; and Stephano de Bagnona, one of the apostolic scribes; with several others of inferior note. The cardinal Riario, then at Pisa, was likewise an instrument in the conspiracy; but he can hardly be considered as an agent, for he was kept ignorant of what was going on, and enjoined only to obey whatever directions he might receive from the archbishop of Pisa.

The assassination of the illustrious youths was fixed for Sunday, April 26. 1478; the place the cathedral of Florence, at the moment the host was to be elevated; and their murder was to be the signal for seizing and expelling from the walls of the city all their relations and friends. What a transaction this for one who presumed to style himself the vicar of Christ, the common father of Christendom, to patronize!

The fatal day arrived, and Lorenzo was already in the church; but Juliano remained at home, occasioned by a slight indisposition. The conspirators, determining not to lose one of their victims, went to invite, to intreat him, to go. They embraced (B), and led him, by a tender violence, to the cathedral. The signal was given

(B) The assassins embraced Juliano, to discover whether he wore any secret armour, that they might know where to strike with the surest aim

Medic given by the elevation of the consecrated wafer; and whilst the people fell upon their knees to adore, the assassins rose, and, as was concerted, two of them, Francisco Pazzi and Barnardo Bandini, fell upon Juliano. The latter directed his poignard so truly, that it entered into the bosom of the unoffending youth, and he fell mortally wounded at his feet.

In a moment, as must be supposed, all was confusion. Lorenzo, alarmed, put himself in a posture of defence, when, in an instant, Antonio of Volterra, and Stephano a priest, the dependant of the archbishop, who, upon Giovanni Battisti's declining the infamous task, undertook his destruction, rushed upon him as their destined prey. The contest continued some time. Lorenzo had received a wound in his neck, and seemed to contend for his life in vain; but a servant, whom he had lately relieved from prison, inspired by gratitude, heroically threw himself between his beloved lord and his assassins, receiving in his body those weapons that were aimed at the breast of Lorenzo. This fidelity saved him; for by one vigorous effort he broke from Antonio and Stephano, and with a few friends rushed into the sacristy, shutting the doors behind them, which were of brass. Apprehensions being entertained, that the weapon which had wounded him was poisoned, a young man sucked the wound, endangering his own life to save that of Lorenzo.

The rage of the people to see one of their favourites expiring, and the other covered with blood, was inexpressible. The cardinal Riario found it difficult to save his life at that altar which he had stained by so horrid a deed, and to which he then fled for protection.

Whilst this infamous scene was acting in the cathedral, others of the conspirators were attempting to seize the Palazzo; but with no better success. The archbishop Salviatti, who had undertaken to head them, gave the magistrates suspicion by those violent emotions which agitated his whole frame. The nine senators who composed the magistracy, including the gonfalonier, who had been appointed by, and were, in other words, the privy council of the Medici, immediately attacked those who intended to have surprised them; and Salviatti and his followers had no sooner gained the second floor, than they found themselves prisoners.

Jacobo Pazzi soon appeared in the street, proclaiming, with exultation, the murder of Juliano; and inviting the Florentines to free themselves from the Medicean slavery; but perceiving that he was not joined by the people, the magistrates sent off 100 horse to the rescue of Lorenzo. This was the more to be commended, because they continued to be assaulted by the conspirators, who, finding their situation desperate, forced themselves to the ground floor, determining, if possible, to seize the Palazzo. The magistrates, with their attendants, acted with such resolution and valour, that as often as they gained an entrance, they drove them back, killing some of the assailants upon the spot, others they threw out of the windows upon the pavement; and to strike an awe into those that were without, they had the boldness and virtue to hang the archbishop from one of the windows, dressed as he was in his pontifical robes, with Poggio, another of the chief conspirators. Florence resounded in every part with the exclamation—Medici, Medici! down with their enemies!

Lorenzo was liberated from that part of the cathedral to which he had fled, and conveyed home in triumph, where his wounds were attended to, and where he found himself surrounded by his most valuable friends, to whom he was endeared by the shocking occurrences of the day. His partizans, however, did not spend their time only in lamentations for the death of one of the brothers, and exultations for the preservation of the other; they united in pursuing the conspirators, sparing none that fell into their hands. Jacobo Pazzi was taken flying with his forces into Romania, and immediately hung. An officer of the pope's, who commanded a brigade under count Hirronimo, had alone the favour of decapitation. Bandini fled privately to Pisa, thence to Naples, and, lastly, to Constantinople; but Mahomet, to oblige Lorenzo, seized, and sent him back; and he was hung out of the same window from which the archbishop had suffered. An embassy was sent from Florence to thank the sultan in the name of the republic.

Throughout the whole of this just but dreadful retribution, Lorenzo had exerted all his influence to restrain the indignation of the populace. He entreated that they would resign to the magistrates the task of ascertaining and of punishing the guilty, lest the innocent should be incautiously involved in destruction; and his appearance and admonitions had an instantaneous effect. By his moderation, and even kindness to the relatives of the conspirators, he sought to obliterate the remembrance of past disturbances; and by his interference, even the survivors of the Pazzi were restored to their honours, of which they had been deprived by a decree of the state.

The generosity and moderation of Lorenzo had no effect on the temper of Sixtus, who solemnly excommunicated him, the gonfalonier, the magistrates, and their immediate successors; and in the bull which he issued on this occasion, he styles Lorenzo de Medici "the child of iniquity, and the nursling of perdition!" Not content with this ebullition of resentment, he suspended the bishops and clergy of the Florentine territories from the exercise of their spiritual functions; thus laying the whole republic under an interdict. This had been a formidable weapon in the hands of his predecessors, who had, by means of it, overawed the most powerful monarchs; but the general character of Sixtus was so infamous, and his present injustice so manifest, that by the exertions of the bishop of Arezzo, a convocation was held in the cathedral church of Florence, in which Sixtus was accused of *fornication* and *adultery*, with other infamous vices; declared to be the principal instigator of the conspiracy against the Medici; and the sentence of excommunication which he had fulminated against Lorenzo and the Florentine magistrates was called in direct terms, the "execrable malediction of a damned judge (*maledictam maledictionem damnatissimi judicis*)!"

How such language could be reconciled to the notions which then prevailed of the sanctity of the pope, and the plenitude of his power, it is needless to inquire; but the reader will not be surprised that the prelates, who made use of it, paid no regard to the interdict of Sixtus. The pontiff, however, did not relax from his purpose. Whilst he brandished with one hand the spiritual weapon, which the Florentines treated with such contempt, in the other, he grasped a temporal sword, which he now openly, as he had before secretly, aimed at the breast of Lorenzo. At his instigation the king of Naples dispatched

Medici. dispatched an envoy to Florence, to require the citizens to banish Lorenzo from the Tuscan territories, if they would not incur the vengeance both of him and of the pope. These threats produced not the intended effect; for the Florentines avowed their firm resolution to suffer every extremity, rather than betray the man whom they considered as guardian of the republic. War therefore was commenced; and the republic was on the point of being ruined, when Lorenzo taking advantage of a truce, threw himself, with a resolution not to be equalled, into the hands of the king of Naples. He judged, perhaps, that any stipulations for his personal safety would be useless with a prince who had sported with honour, justice, mercy, and the most solemn treaties. But, whilst all viewed him as a victim who had devoted himself to save his country, he, by persuasive eloquence, obtained of this crafty perfidious monarch a separate peace, and returned to Florence crowned with a success that no one thought possible, and where he was received as its tutelar deity. The pope, however, continued inflexible, till a descent of the Turks upon Italy restored him to his senses, and made him willing to receive the submission of Florence, and reconcile its inhabitants to the church.

Soon after the termination of the hostilities between Sixtus and the republic of Florence, Lorenzo began to unfold plans for securing the peace of Italy, which confer the highest honour on his political life. To counterpoise all the jarring interests of the petty states of which that country was composed, to restrain the powerful, succour the weak, and to unite the whole in one firm body which might be able, on the one hand, successfully to oppose the formidable power of the Turks, and, on the other, to repel the incursions of the French and Germans, were the important ends which this great man proposed to accomplish. But before he engaged in these momentous undertakings, he had further personal dangers to encounter. By the instigation of Cardinal Riario, and some Florentine exiles, one Battista Frescobaldi, with only two assistants, undertook to assassinate him in the church of the Carmeli, on the festival of the ascension 1481; but the plot was discovered, the conspirators executed, and Lorenzo henceforth seldom went abroad without being surrounded by a number of tried friends.

Lorenzo was now at liberty to prosecute his benevolent purposes; and after contributing to the expulsion of the Turks from Italy, he set himself in good earnest to support the weak states against the encroachments of the more powerful. This necessarily embroiled the republic at one time with the pope, at another with the king of Naples; now with the Venetians, and then with the Duke of Milan: but when some exclaimed against him as being too precipitate in involving the republic in dangerous and expensive wars, he explained to them the necessity of maintaining the balance of power, if they would preserve the independence of their own state; and so completely had he made himself master of this subject, that he convinced the most incredulous of the propriety of his measures, which, in 1488, introduced general tranquillity into Italy

At this period, the city of Florence was at its highest degree of prosperity. The vigilance of Lorenzo had secured it from all apprehensions of external attack; and his acknowledged disinterestedness and moderation had almost extinguished that spirit of internal dissension for which it had been so long remarkable. The Florentines gloried in their illustrious citizen, and were gratified by numbering in their body a man who wielded in his hands the fate of nations, and attracted the respect and admiration of all Europe.

Yet amidst public affairs so intricate and so momentous, such was the capacity of this man's mind, and such his versatility of genius, that, for the greater part of his life, he carried on a commerce as extensive as that of his grandfather, whilst he afforded still greater encouragement to learning and learned men. Cosmo had greatly promoted the study of the ancient languages and ancient philosophy. Lorenzo did the same thing; but he did much more; he encouraged the cultivation of his own tongue, which had been neglected since the age of Petrarca; and by setting a great example himself, he produced a race of Italian poets, which have hardly been surpassed in any age or nation. To enumerate even the names of the elegant scholars whom he patronised, would extend this article far beyond its limits. In the academy of Pisa, of which mention has been already made, the studies were chiefly confined to the Latin language, and to those sciences of which it was the principal vehicle. At Florence the Greek tongue was taught under the sanction of a public institution, either by native Greeks or learned Italians, whose services were procured by the diligence of Lorenzo de Medici, and repaid by his bounty. He placed Michael Angelo at the head of an academy, which he erected for painting and sculpture, furnishing it with the best models of antiquity. He built and endowed a public library, and sent Lascaris, of imperial descent, to Constantinople more than once, to procure Greek manuscripts. For father Moriano, the orator, a monastery was built; and Florence owed many of her finest edifices to him. Politiano and Ficino were among his most intimate friends; and it is not perhaps too much to say, that he did more for letters and science and art than any other individual that ever existed. His own acquirements in learning were great; and his poetry, of which the reader will find many specimens in the elegant work of Roscoe, was exquisite.

Is it surprising, when we examine Lorenzo's character, that all Italy, all Christendom, even the Mahometans, gave him the most flattering marks of approbation, and strove who should oblige him most, by presenting him with whatever was rare and valuable? His palace was constantly filled with men famous in every elegant, every useful science, and the neighbouring princes flocked to it as to the temple of wisdom. The celebrated prince of Mirandola, on his account, chose Florence for his residence, and died there.

To a most engaging person was added each grace, and every accomplishment. He was the favourite of the ladies, the envy of the men, and the admiration of both. The statesman of his time; unrivalled in chivalry; one of the most eminent orators that the world has produced. His poetic merit, with his judgment in, and patronage of that art, procured him the title of "Father of the Muses." In liberality to his fellow-citizens, as well as in every other respect, except as a general, he exceeded even Cæsar himself; and had not peace been his dear delight, his talents would have made him a consummate commander. Yet with all these superior

point of accompliſhments, he did not think it beneath him to indulge in amuſements which perſons, leſs wiſe, would have thought an impeachment of their underſtanding, and he would often ſeek pleaſure in his nurſery, ſpending hours there in all the frivolous pranks of childiſh diverſion. In fine, "the gravity of his life, if compared with its levity, muſt make him appear as a compoſition of two different perſons, incompatible, and, as it were, impoſſible to be joined with the other."

Lorenzo, like moſt other great men, had wiſhed to ſpend his laſt years in the tranquillity of retirement. He therefore at an early period wound up his mercantile concerns, and divided his time between the cares of the republic at Florence, and the cultivation of his eſtates in the country. He wiſhed even to diveſt himſelf of all public concerns, and get his ſecond ſon Giovanni admitted into holy orders at the age of ſeven years, that he might be fit for eccleſiaſtical preferment before he ſhould be deprived of the protection of his father. The young eccleſiaſtic, who afterwards made ſuch a figure as Leo X. was accordingly appointed by Louis XI. of France, abbot of Fonte Dolac, before he was eight years of age; and by Innocent VIII. a cardinal, when he was little more than thirteen. This added much to the influence of the family, not only in the Tuſcan ſtates but through all Italy; and Lorenzo having introduced his eldeſt ſon into public life, and accompliſhed a marriage between him and the daughter of a noble family at Rome, thought he might commit the affairs of the republic in a great meaſure to Piero, and indulge his own taſte in the converſation of his learned friends. This dream of felicity however was not realized. Early in the year 1492, he was attacked by a diſeaſe, under which he had long laboured, with ſuch violence, that on the 8th of April he died in the midſt of his weeping friends, after having taken of them, one by one, an affectionate farewel, and given to his ſon Piero much ſalutary counſel, which he thought not fit to follow.

The character of this great and good man is developed in the detail which we have given of his conduct through life: But it may not be improper to add, that ſuch was the love and veneration of the citizens to him, that the phyſician, who had attended him on his deathbed, afraid to return to Florence, left the houſe in a ſtate of diſtraction, and plunged himſelf into a well. Throughout the reſt of Italy the death of Lorenzo was regarded as a public calamity of the moſt alarming kind. Of the arch which ſupported the political fabric of that country he had long been conſidered as the centre, and his loſs ſeemed to threaten the whole with immediate deſtruction. When Ferdinand king of Naples was informed of the event, he exclaimed, "This man has lived long enough for his own glory, but too ſhort a time for Italy."

MEDICINA FORENSIS, is a phraſe uſed in Germany to denote thoſe parts of anatomical and phyſiological knowledge, which enable phyſicians and ſurgeons to decide certain cauſes as judges in courts of juſtice. In that country it has long been law and cuſtom (if we miſtake not, by the Caroline code of Charles V.) to refer caſes of *poiſoning, child murder, rape, pregnancy, impotency, idiotiſm*, &c. to the medical faculty, which, in the univerſities and ſome other great towns, is conſtituted into a kind of court for the trial of ſuch queſtions. In this country there are no ſuch courts; but in criminal trials medical gentlemen are often called upon to deſcribe the ſymptoms of *poiſoning, child murder, rape*, &c. and therefore it becomes them to obtain an accurate knowledge of theſe ſymptoms, and to ſtore their memories with a number of minute facts, to which they may have occaſion to appeal when giving their evidence.

The importance of this ſubject induced the profeſſor of the inſtitutes of phyſic in the univerſity of Edinburgh to reſolve lately to read an annual courſe of lectures on MEDICAL JURISPRUDENCE. This, we doubt not, will prove a valuable courſe; for though it is hardly conceivable that, under the head *medical juriſprudence*, any *knowledge* can be communicated which a well educated phyſician would not neceſſarily have acquired, without attending ſuch a courſe; yet it is very obvious, that the recollection of the young phyſician may receive great aid from his liſtening to the well arranged lectures of an accurate profeſſor. From theſe lectures he may ſtore his mind with a collection of aphoriſms which ſhall be always ready on the day of examination; or the lectures themſelves may be delivered in queſtions and anſwers with all the formalities of a criminal court.

We have heard it obſerved, that to attend a courſe of ſuch lectures would be of the utmoſt advantage to all who may be called upon to ſerve as jurymen in criminal trials; but of the truth of this obſervation we are more than doubtful. Perſons who are only *half* inſtructed are always conceited of their own attainments; and men not acquainted with anatomy and phyſiology cannot be *more* than half inſtructed by the ableſt courſe poſſible to be given of medical juriſprudence. Such perſons indeed can hardly avoid miſtaking the ſenſe of the profeſſor's language, however perſpicuous that language may be. Of this we had lately a very ſtriking inſtance. A gentleman, by no means illiterate, though a ſtranger to anatomical and phyſiological ſcience, was expatiating to the writer of this article upon the general importance of medical juriſprudence, a courſe of which, he ſaid, he had attended for the ſole purpoſe of qualifying himſelf for diſcharging the important duties of a juryman. Upon being aſked what he had learned? he replied, that he had been taught, among other things which we thought frivolous, to diſcern, from the ſymptoms of *hanging*, whether the dead man had been hanged by *himſelf* or by *another*. We need not ſurely obſerve, that no ſuch leſſon was ever taught in any univerſity, or by any medical lecturer; but it is worthy of conſideration, whether lectures on medical juriſprudence may not have the moſt pernicious effects on the minds of men ſo little qualified as this gentleman to profit by them. To the regularly educated phyſician and ſurgeon ſuch lectures may prove uſeful; to the plain citizen, not ſkilled in anatomy and phyſiology, they muſt prove dangerous; as their only tendency is to make him deſpiſe the evidence given before him by the regular phyſician or ſurgeon; to place implicit confidence in his own ſuperficial knowledge; and thus to decide at random on the life or death of his fellow creature:

> A little learning is a dangerous thing;
> Drink deep, or taſte not the Pierian ſpring.

MEDINA, the capital of the kingdom of Woolli in Africa, is ſituated in 13° 40′ N. Lat. and 12° 40′ W. Long. It is a place of conſiderable extent, and may contain from 800 to 1000 houſes. It is fortified in the

common

Medusa. Megameter.

common African manner, by a surrounding high wall built of clay, and an outward fence of pointed stakes and prickly bushes; but the walls are neglected, and the outward fence has suffered considerably from the active hands of busy housewives, who pluck up the stakes for firewood. Mr Park passed through it on his route eastward, and was treated with much kindness both by the king and the people. The good old sovereign warned him of the dangers he was about to encounter, and endeavoured to persuade him to relinquish all thoughts of his journey eastward; but when he could not prevail, he gave him a guide, who conducted him in safety to Koojar, the frontier town of the kingdom towards Bondou, from which it is separated by an intervening wilderness of two days journey. Here our author was presented, by way of refreshment, with a liquor which tasted so much like the strong beer of his native country (and very good beer too), as to induce him to inquire into its composition; and he learned, with some degree of surprise, that it was actually made from corn which had been previously malted, much in the same manner as barley is malted in Great Britain: a root yielding a grateful bitter was used in lieu of hops, the name of which he forgot; but the corn which yields the wort is the *holcus spicatus* of botanists.

MEDUSA. In addition to the different species of this genus of vermes described in the *Encyclopædia*, that which is represented in two different attitudes, fig. 1. and 2. and which strongly resembles a bagpipe in shape, may be worthy of notice. It is merely a white transparent vesicle, furnished with several blue tentacles yellowish at their extremity; its long tail, which is also blue, appears to be composed of a number of small glandulous grains, flattened and united together by a gelatinous membrane. The upper part of the vesicle exhibits a kind of seam with alternate punctures of three different sizes; its elongated part, which may be considered as the head of the animal, is terminated by a single trunk, the exterior edge of which is fringed with 25 or 26 tentacles, much smaller than those which originate from the insertion of its long tail, and the number of which sometimes amounts to 30. By means of these last, the diameter of which it is capable of increasing at pleasure by forcing in a little of the air from its body, it fixed itself to the side of the vessel, in which it was placed, in such a manner as that the extremity of some of its tentacles occupied a surface of two or three lines from its body. The most moveable part of the vesicle is its elongation, or the head of the animal, as it is by means of this that it performs its different motions. The rounded substance, marked by the letter P, is situated in the centre of the larger tentacles, which are firmly fixed to the body of the animal near its tail; and is only an assemblage of a few minute gelatinous globules, from the middle of which arise other larger globules, with a small peduncle, about the middle of which is fixed a curved bluish coloured body, which is represented magnified in two positions at R. Martiniere, the naturalist, who accompanied Perouse in his voyage round the world, met with this animal in about the 20th degree of lat. and 179° of long. east from Paris.

Plate XXXVI.

MEGAMETER, a name sometimes given to the MICROMETER, which see, *Encycl.*

Mehal. Meninski.

MEHALL, in the language of Bengal, a place or district.

MENINSKI (Franciscus), a most celebrated German orientalist, was born in Lorraine, then subject to the emperor, in the year 1623; and for copiousness of learning, elegance of genius, and profound knowledge of languages, particularly those of the East, proved undoubtedly one of the principal ornaments of the age in which he lived. He studied at Rome under Giattino. When he was about 30, his love of letters induced him to accompany the Polish ambassador to Constantinople, where he studied the Turkish language under Bobovius and Ahmed, two very skilful teachers. So successful was he in this study, that when he had been there only two years, the place of first interpreter to the Polish embassy at the Porte was promised to him. When the place became vacant, he was accordingly appointed to it, and obtained so much credit by his conduct, that, after a time, he was sent for into Poland, and again sent out with full powers as ambassador to the Porte. For his able execution of this office, he was further honoured, by being naturalized in Poland; on which occasion he added the Polish termination of *ski* to his family name, which was Menin. Being desirous afterwards to extend his sphere of action, he went to the court of the emperor as interpreter of oriental languages in 1661. Here also, as in other instances, his talents and behaviour obtained the highest approbation; on which account he was not only sent as interpreter to several imperial ambassadors at the Porte, but was intrusted in many important and confidential services; and, in 1669, having paid a visit to the holy sepulchre at Jerusalem, was made one of the knights of that order. After his return to Vienna he was advanced to further honours; being made one of the counsellors of war to the emperor, and first interpreter of oriental languages. At Vienna he died at the age of 75, in the year 1698. His great work, 1. The "Thesaurus linguarum orientalium," was published at Vienna in 1680, in 4 vols folio; to which was added, in 1687, another volume, intitled, "Complementum Thesauri linguarum orientalium, seu onomasticum Latino-Turcico-Arabico Persicum." The former volumes having become extremely scarce, partly on account of the destruction of a great part of the impression, in the siege of Vienna by the Turks in 1683, a design was formed some time ago in England of reprinting the work, by a society of learned men, among whom was Sir William Jones. But as this undertaking, probably on account of the vast expence which must have been incurred, did not proceed, the empress queen Maria Theresa, who had heard of the plan, took it upon herself, and with vast liberality furnished every thing necessary for its completion. In consequence of this, it was begun to be splendidly republished at Vienna in 1780, with this title: "Francisci a Mesgnien Meninski Lexicon Arabico-Persico-Turcicum, adjecta ad singulas voces et Phrases interpretatione Latina, ad usitatiores, etiam Italica." Of this edition only two vols folio are yet published, extending no farther than *zal*, the ninth letter of the Arabic alphabet, which is about a third of the whole. The delay of the rest is much to be lamented. In this edition, say the editors, the Lexicon of Meninski may be said to be increased, diminished, and amended. *Increased*, because many Arabic and Persian

words

Meninſki, Merchetta. words are added, from Wankuli and Ferhengi, the beſt Arabic and Perſic lexicographers whom the Eaſt has produced; and from Herbelot are inſerted the names of kingdoms, cities, and rivers, as well as phraſes in common uſe among the Turks, &c. *Diminiſhed*, becauſe many uſeleſs ſynonyma are omitted, which rather puzzled than aſſiſted the ſtudent; as well as all the French, Poliſh, and German interpretations, the Latin being conſidered as ſufficient for all men of learning. *Amended*, with reſpect to innumerable typographical errors; which, however, from a work of this nature, no care can perhaps altogether exclude. The other works of Meninſki were occaſioned chiefly by a violent conteſt between him and a man named J. B. Podeſta, in which much acrimony was employed on both ſides. Theſe it is hardly worth while to enumerate, but they may all be ſeen in the account of his life from which this article is taken (A). It ſhould be obſerved, however, that in 1671, Podeſta publiſhed a book, intitled, "Prodromus novi linguarum orientalium collegii, juſſu Aug. &c. erigendi, in Univ. Viennenſi;" to which Meninſki oppoſed, 2. "Meninſkii Antidotum in Prodromum novi ling. orient. collegii, &c." 4to. But ſuch was the credit of his antagoniſt in the univerſity, that ſoon after there came out a decree in the name of the rector and conſiſtory, in which that antidote of Meninſki's is proſcribed and prohibited, for ſix ſpecific reaſons, as impious and infamous. Meninſki was defended againſt this formidable attack by a friend, in a ſmall tract, intitled, "Veritas defenſa, ſeu juſtitia cauſæ Dn. F. de M. M [Meninſki] contra infame decretum Univerſitatis Viennenſis, Anno 1674, 23 Novembris, &c. ab Amico luci expoſita, Anno 1675," in which this friend expoſes, article by article, the falſehood of the decree, and exclaims ſtrongly againſt the arts of Podeſta. This tract is in the Britiſh Muſeum. Podeſta was oriental ſecretary to the emperor, and profeſſor of thoſe languages at Vienna; but is deſcribed in a very ſatirical manner by the defender of Meninſki. "Podeſta, natura Semi Italus, ſtatura nanus, cæcutiens, balbus, imo bardus repertus, aliiſque vitiis ac ſtultitiis plenus, adeoque ad diſcendas linguas orientales inhabilis." A liſt of the works of Podeſta is, however, given by the late editors of Meninſki.

MERCHETTA, or *Marchetta Mulierum*, is commonly ſuppoſed to have been a right which, during the prevalence of the feudal ſyſtem, the lord had of paſſing the firſt night after marriage with his female villain. This opinion has been held by the greater part of our antiquarians; and we have adopted it in our hiſtory of SCOTLAND publiſhed in the *Encyclopædia*. It appears, however, to be a miſtake. That there was a cuſtom called *merchetta mulierum*, which prevailed not only in England, Scotland, Wales, and the iſle of Guernſey, but alſo on the continent, is indeed a fact unqueſtionable; but Mr Aſtle has clearly proved, that, inſtead of *Archæologia, vol. xii.* being an adulterous connection, the *merchetta* was a compact between the lord and his vaſſal for the redemption of an *offence* committed by that vaſſal's *unmarried* daughter. He admits, however, that it denoted likewiſe a fine paid by a *ſokeman* or a *villan* to his lord, for a licence to marry his daughter to a free man; and that if the vaſſal gave her away without obtaining ſuch a licence, he was liable to pay a heavier fine. He quotes two authorities in ſupport of his opinion from Bracton; one of which we ſhall tranſcribe, as being alone complete evidence.

"Ric. Burre tenet unum meſuagium et debet telliagium ſectam curiæ, et *merchet*, hoc modo, *quod ſi maritare voluerit filiam ſuam cum quodam libero homine, extra villam, faciet pacem domini pro maritagio, et ſi eam maritaverit alicui cuſtumario villæ, nihil debuit pro maritagio.*"

"The probable reaſon of the cuſtom (ſays Mr Aſtle) appears to have been this. Perſons of low rank, reſiding on an eſtate, were either *aſcripti glebæ*, or were ſubjected to ſome ſpecies of ſervitude ſimilar to the *aſcripti glebæ*. They were bound to reſide on the eſtate, and to perform ſeveral ſervices to the lord. As women neceſſarily followed the reſidence of their huſbands, the conſequence was, that when a woman of low rank married a ſtranger, the lord was deprived of part of his live ſtock; he therefore required a fine to indemnify him for the loſs of his property." Further particulars on the *merchetta* are to be found in the Appendix to vol. 1ſt of *Sir David Dalrymple's Annals of Scotland*.

Meridian, Meſolabe. MERIDIAN LINE, an arch, or part of the meridian of the place, terminated each way by the horizon. Or, a meridian line is the interſection of the plane of the meridian of the place with the plane of the horizon, often called a north-and-ſouth line, becauſe its direction is from north to ſouth.

In the article ASTRONOMY (*Encycl.*), nº 376 and 377, we have given two methods of drawing a meridian line; but it may be proper to add, in this place, the following improvement of the former of theſe from Dr Hutton's Mathematical Dictionary. "As it is not eaſy (ſays the Doctor) to determine preciſely the extremity of the ſhadow, it will be beſt to make the ſtile flat at the top, and to drill a ſmall hole through it, noting the lucid point projected by it on the ſeveral concentric circles, inſtead of marking the extremity of the ſhadow itſelf on theſe circles."

We ſhall give another method of drawing a meridian line from the ſame valuable dictionary.

"Knowing the ſouth quarter pretty nearly, obſerve the altitude FE of ſome ſtar on the eaſt ſide of it, and Plate XXXV. not far from the meridian HZRN: then, keeping the quadrant firm on its axis, ſo as the plummet may ſtill cut the ſame degree, direct it to the weſtern ſide of the meridian, and wait till you find the ſtar has the ſame altitude as before, as *fe*. Laſtly, biſect the angle EC*e*, formed by the interſection of the two planes in which the quadrant has been placed at the time of the two obſervations, by the right line HR, which will be the meridian ſought."

Magnetical MERIDIAN, is a great circle paſſing thro' or by the magnetical poles; to which meridians the magnetical needle conforms itſelf. See MAGNETISM, *Suppl.*

MESOLABE, or MESOLABIUM, a mathematical inſtrument invented by the ancients, for finding two mean

(A) We have taken this article from the Biographical Dictionary; the editors of which took it from the life of Meninſki prefixed to the new edition of his great work.

mean proportionals mechanically, which they could not perform geometrically. It consists of three parallelograms, moving in a groove to certain intersections. Its figure is described by Eutocius, in his Commentary on Archimedes. See also Pappus, lib. 3.

MESO-LOGARITHM, a term used by Kepler to signify the logarithms of the cosines and cotangents.

MESURATA, a seaport of the kingdom of Tripoli, in Africa. A caravan proceeds from this place to Fezzan, and other interior parts toward the south of Africa. It is 260 miles north of Mourzook. E. lon. 15. 5. N. lat. 31. 3.

METALLIC TRACTORS. See PERKINISM in this *Suppl.*

METONIC CYCLE, called also the *Golden Number*, and *Lunar Cycle*, or *Cycle of the Moon*, that which was invented by Meton the Athenian; being a period of 19 years. See CYCLE, *Encycl.*

MHA RAJAH, the highest title of Hindoos.

MICROCOUSTICS, or MICROPHONES, instruments contrived to magnify small sounds, as microscopes do small objects.

MICROCOSMIC SALT. See CHEMISTRY-*Index*, *Suppl.*

MIDDLE LATITUDE, is half the sum of two given latitudes; or the arithmetical mean, or the middle between two parallels of latitude. Therefore,

If the latitudes be of the same name, either both north or both south, add the one number to the other, and divide the sum by 2; the quotient is the middle latitude, which is of the same name with the two given latitudes. But

If the latitudes be of different names, the one north and the other south; subtract the less from the greater, and divide the remainder by 2, so shall the quotient be the middle latitude, of the same name with the greater of the two.

MIDSUMMER-DAY, is held on the 24th of June, the same day as the nativity of St John the Baptist is held.

MILK, or MILKYET, property in Bengal.

MILLS of various kinds are described in the article MECHANICS (*Encycl.*); and he who shall study that article, together with *Water-Works*, and MACHINERY, in this *Supplement*, will have a sufficient knowledge of the principles upon which mills must be constructed so as that they may produce their proper effects. The subject is introduced into this place merely to put it into the power of our countrymen to adopt, if they shall think fit, the improvements which have been made in the machinery of flour mills in America.

The chief of these consist in a new application of the screw, and the introduction of what are called elevators, the idea of which was evidently borrowed from the chain pump. The screw is made by sticking small thin pieces of board, about three inches long and two wide, into a cylinder, so as to form the spiral line. This screw is placed in a horizontal position, and by turning on its axis it forces wheat or flour from one end of a trough to the other. For instance, in the trough which receives the meal immediately coming from the stones, a screw of this kind is placed, by which the meal is forced on, to the distance of six or eight feet, perhaps, into a reservoir; from thence, without any manual labour, it is conveyed to the very top of the mill by the elevators, which consist of a number of small buckets of the size of tea cups, attached to a long band that goes round a wheel at the top, and another at the bottom of the mill. As the band revolves round the wheels, these buckets dip into the reservoir of wheat or flour below, and take their loads up to the top, where they empty themselves as they turn round the upper wheel. The elevators are inclosed in square wooden tubes, to prevent them from catching in any thing, and also to prevent dust. By means of these two simple contrivances no manual labour is required from the moment the wheat is taken to the mill till it is converted into flour, and ready to be packed, during the various processes of screening, grinding, sifting, &c.

That this is a considerable improvement is obvious; and we are not without hopes that it may be adopted. The licentiousness of an English mob has indeed persecuted an Arkwright, expelled the inventor of the fly-shuttle from his native country, and by such conduct prevented the re-erection of the Albion mills, and the general establishment of saw-mills through the kingdom; but their sovereignty perhaps will not be roused by so easy and simple a contrivance as this to lessen the quantity of manual labour. For an account of the Dutch oil-mill, which was somehow omitted in its proper place in the *Encyclopædia*, see OIL-MILL in this *Supplement*.

MINERALOGY

Definition. IS a science, the object of which is the description and arrangement of *inorganic bodies* or *minerals*; or of *all* the bodies which belong to our globe, excepting *animal* and *vegetable substances*.

Since the publication of the article MINERALOGY, *Encycl.* scarcely a single day has passed without the discovery of some new mineralogical fact, or the detection of some old and unsuspected error. These improvements cannot be overlooked in the present *Supplement*. But they are so numerous in every part of the science, that we can hardly notice them without giving a pretty complete view of the present state of mineralogy. This will scarcely occupy more room, and must be much more useful as well as entertaining, than an undigested mass of annotations and remarks. We undertake this task the more readily, because in the article MINERALOGY in the *Encyclopædia*, the improvements of Mr Werner and his disciples, to which the science is indebted for a great part of its present accuracy, have been entirely overlooked.

The object of mineralogy is twofold. 1. To *describe* every mineral with so much accuracy and precision, that it may be easily distinguished from every other mineral; 2. To *arrange* them into a system in such a manner that every mineral may be easily referred to its proper place, and that a person may be able, merely by the help of the system, to discover the *name* of any mineral whatever. When these two objects are accomplished, mineralogy, Object.

neralogy, strictly so called, is completed. But were we to stop here, the utility of the science, if it would be entitled to the name of science, could hardly be considered as very great. We must therefore apply *chemistry* to discover the ingredients of which minerals are composed, and to detect, if possible, the laws which these ingredients have observed in their combination. Thus we shall really extend our knowledge of inorganic nature, and be enabled to apply that knowledge to the improvement of almost every art and manufacture.

3 Division of the article.

Mineralogy naturally divides itself into three parts. The *first* treats of the method of describing minerals; the *second*, of the method of arranging them; and the *third* exhibits them in a system described and arranged according to the rules laid down in the two first parts. These three parts shall be the subjects of the following chapters; and we shall finish the article with a chapter on the chemical analysis of minerals.

Chap. I. Of the Description of Minerals.

Nothing, at first sight, appears easier than to describe a mineral, and yet, in reality, it is attended with a great deal of difficulty. The mineralogical descriptions of the ancients are so loose and inaccurate, that many of the minerals to which they allude cannot be ascertained; and consequently their observations, however valuable in themselves, are often, as far as respects us, altogether lost. It it obvious, that to distinguish a mineral from every other, we must either mention some peculiar property, or a collection of properties, which exist together in no other mineral. These properties must be described in terms rigidly accurate, which convey precise ideas of the very properties intended, and of no other properties. The smallest deviation from this would lead to confusion and uncertainty. Now it is impossible to describe minerals in this manner, unless there be a peculiar term for each of their properties; and unless this term be completely understood. Mineralogy therefore must have a language of its own; that is to say, it must have a *term* to denote every mineralogical property, and each of these terms must be accurately defined. The language of mineralogy was invented by the celebrated Werner of Freyberg, and first made known to the world by the publication of his treatise on *the external characters of minerals*. Of this language we shall give a view in the following general description of the properties of minerals (A).

4 Properties of minerals.

The properties of minerals may be divided into two classes. *1st*, Properties discoverable without destroying the texture of the mineral; *2d*, Properties resulting from the action of other bodies on it. The first class has, by Werner and his disciples, been called *external* properties, and by some French writers *physical*; the second class has been called *chemical*.

The *external* properties may be arranged under the following heads:

External Characters.

1 Figure.	8 Ductility.	14 Sound.
2 Surface.	9 Fracture.	15 Smell.
3 Transparency.	10 Texture.	16 Taste.
4 Colour.	11 Structure.	17 Gravity.
5 Scratch.	12 Fragments.	18 Magnetism.
6 Lustre.	13 Feel.	19 Electricity.
7 Hardness.		

I. By FIGURE is meant the shape or form which a mineral is observed to have. The *figure* of minerals is either *regular*, *particular*, or *amorphous*. 1. Minerals which assume a regular figure are said to be crystallized*. The *sides* of a crystal are called *faces*; the sharp line formed by the inclination of two faces is called an *edge*; and the corner, or angle, formed by the meeting of several edges in one point, is called a *solid angle*, or simply *an angle*. Thus a cube has six faces, twelve edges, and eight angles. 2. Some minerals, though not crystallized, affect a *particular* figure. These particular figures are the following: *Globular*, like a globe; *oval*, like an oblong spheriod; *ovate*, like an egg; *cheese-shaped*, a very flattened sphere; *almond-shaped*, like an almond; *centicular*, like a double convex lense, compressed and gradually thinner towards the edges; *cuneiform*, like a wedge; *nodulous*, having depressions and protuberances like a potatoe; *botryoidal*, like grapes closely pressed together; *dentiform*, longish and tortuous, and thicker at the bottom than the top; *wireform*, like a wire; *capillary*, like hair, finer than the preceding; *retiform*, threads interwoven like a net; *dendritic*, like a tree, having branches issuing from a common stem; *shrubform*, branches not arising from a common stem; *coraloidal*, branched like coral; *stalactitical*, like isicles; *clavated*, like a club, long, and thicker at one end than another; *fasciform*, long straight cylindrical bodies, united like a bundle of rods; *tubular*, cylindrical and hollow. 3. When minerals have neither a regular nor particular shape, they are said to be *amorphous*. 5

5 Figure.

* See Chemistry, Part II. Chap. iv. Sup.

6 Surface.

II. By SURFACE is meant the appearance of the external surface of minerals. The *surface* is either *uneven*, composed of small unequal elevations and depressions; *scabrous*, having very small *sharp* and rough elevations, more easily felt than seen; *drusy*, covered with very minute crystals; *rough*, composed of very minute *blunt* elevations, easily distinguishable by the feel; *scaly*, composed of very minute thin scale-like leaves; *smooth*, free from all inequality or roughness; *specular*, having a smooth polished surface like a mirror; or *streaked*, having elevated, straight, and parallel lines. This last character is confined to the *surface* of crystals. The *streaks* are either *transverse*; *longitudinal*; *alternate*, in different directions on different faces; *plumose*, running from a middle rib; or *decussated*, crossing each other.

7 Transparency.

III. By TRANSPARENCY is meant the proportion of light which minerals are capable of transmitting. They are *transparent* or *pellucid*, when objects can be seen distinctly through them; *diaphanous*, when objects are seen

(A) The fullest account of Werner's external characters which we have seen in the English language, has been given by Dr Townson in his *Philosophy of Mineralogy*. We have availed ourselves of this book, in order to exhibit some of the latest improvements of Werner and his disciples. The reader may also consult *Werner's Treatise*, published at Leipsic in 1774; or the *French translation* published at Dijon in 1790. See also *Rome de Lisle. Des caracters exterieur des mineraux*. And *Hauy Jour. d'hist. Nat.* II. 56.

External Characters seen through them indistinctly; *subdiaphanous*, when light passes but in so small a quantity that objects cannot be seen through them (B); *opaque*, when no light is transmitted.

When opaque minerals become transparent in water, they are called *hydrophanous*. When objects are seen double through a transparent mineral, it is said to *refract doubly*.

Colour. IV. The colours of minerals may be reduced to eight classes.

1. *Whites.*

Snow white. Pure white.

Reddish white. White with a light tint of red.

Yellowish white. White with a light tint of yellow.

Silver white. Yellowish white with a metallic lustre.

Greyish white. White with a light tint of black.

Greenish white. White with a light tint of green.

Milk white. White with a light tint of blue.

Tin white. Milk white of a metallic lustre.

2. *Greys.*

Bluish grey. Grey with a little blue.

Lead grey. Bluish grey with a metallic lustre.

Pearl grey. Light grey with a slight mixture of violet blue.

Smoke grey. Dark grey with a little blue and brown.

Greenish grey. Light grey tinged with green.

Yellowish grey. A light grey tinged with yellow.

Steel grey. A dark grey with a light tint of yellow and a metallic lustre.

Black grey. The darkest grey with a tint of yellow.

3. *Blacks.*

Greyish black. Black with a little white.

Brownish black. Black with a tint of brown.

Black. Pure black.

Iron black. Pure black with a small mixture of white and a metallic lustre.

Bluish black. Black with a tint of blue.

4. *Blues.*

Indigo blue. A dark blackish blue.

Prussian blue. The purest blue.

Azure blue. A bright blue with scarce a tint of red.

Smalt blue. A light blue.

Violet blue. A mixture of azure blue and carmine.

Lavender blue. Violet blue mixed with grey.

Sky blue. A light blue with a slight tint of green.

5. *Greens.*

Verdigris green. A bright green of a bluish cast.

Seagreen. A very light green, a mixture of verdigris green and grey.

Beryl green. The preceding, but of a yellowish cast.

Emerald green. Pure green.

Grass green. Pure green with a tint of yellow.

Apple green. A light green formed of verdigris green and white.

Leek green. A very dark green with a cast of brown.

Blackish green. The darkest green, a mixture of leek green and black.

Pistachio green. Grass green, yellow and a little brown.

Olive green. A pale yellowish green with a tint of brown.

Asparagus green. The lightest green, yellowish with a little brown and grey.

6. *Yellows.*

Sulphur yellow. A light greenish yellow.

Brass yellow. The preceding, with a little less green and a metallic lustre.

Lemon yellow. Pure yellow.

Gold yellow. The preceding with a metallic lustre.

Honey yellow. A deep yellow with a little reddish brown.

Wax yellow. The preceding, but deeper.

Pyritaceous. A pale yellow with grey.

Straw yellow. A pale yellow, a mixture of sulphur yellow and reddish grey.

Wine yellow. A pale yellow with a tint of red.

Ochre yellow. Darker than the preceding, a mixture of lemon yellow with a little brown.

Isabella yellow. A pale brownish yellow, a mixture of pale orange with reddish brown.

Orange yellow. A bright reddish yellow, formed of lemon yellow and red.

7. *Reds.*

Aurora red. A bright yellow red, a mixture of scarlet and lemon yellow.

Hyacinth red. A high red like the preceding, but with a shade of brown.

Brick red. Lighter than the preceding; a mixture of aurora red and a little brown.

Scarlet red. A bright and high red with scarce a tint of yellow.

Copper red. A light yellowish red with the metallic lustre.

Blood red. A deep red, a mixture of crimson and scarlet.

Carmine red. Pure red verging towards a cast of blue.

Cochineal red. A deep red; a mixture of carmine with a little blue and a very little grey.

Crimson red. A deep red with a tint of blue.

Flesh red. A very pale red of the crimson kind.

Rose red. A pale red of the cochineal kind.

Peach blossom red. A very pale whitish red of the crimson kind.

Mordoré. A dark dirty crimson red; a mixture of crimson and a little brown.

Brownish red. A mixture of blood red and brown.

8. *Browns.*

Reddish brown. A deep brown inclining to red.

Clove brown. A deep brown with a tint of carmine.

Yellowish brown. A light brown verging towards ochre yellow.

Umber brown. A light brown, a mixture of yellowish brown and grey.

Hair brown. Intermediate between yellow brown and clove brown with a tint of grey.

Tombac brown. A light yellowish brown, of a metallic lustre, formed of gold yellow and reddish brown

Bb 2 Liver

(B) After Mr Kirwan, we have denoted these three degrees of transparency by the figures 4, 3, 2. When a mineral is subdiaphanous only at the edges, that is denoted by the figure 1. Opacity is sometimes denoted by 0.

Liver brown. A dark brown; blackiſh brown with a tint of green.

Blackiſh brown. The darkeſt brown.

Colours, in reſpect of intenſity, are either *dark*, *deep*, *light*, or *pale*. When a colour cannot be referred to any of the preceding, but is a mixture of two, this is expreſſed, by ſaying, that the prevailing one *verges* towards the other, if it has only a ſmall tint of it; *paſſes* into it, if it has a greater.

V. By the SCRATCH OR STREAK, is meant the mark left when a mineral is ſcratched by any hard body, as the point of a knife. It is either *ſimilar*, of the ſame colour with the mineral; or *diſſimilar*, of a different colour.

10 uſtre

VI LUSTRE, is the gloſs or brightneſs which appears on the external ſurface of a mineral, or on its internal ſurface when freſh broken. The firſt is called *external*, the ſecond *internal* luſtre. Luſtre is either *common*, that which moſt minerals poſſeſs; *ſilky*, like that of ſilk or mother of-pearl; *waxy*, like that of wax; *greaſy*, like that of greaſe; or *metallic*, like that of metals.

As to the degree, the greateſt is called *ſplendent*, the next *ſhining*, the third *dulliſh*; and when only a few ſcattered particles ſhine, the luſtre is called *dull* (c).

11 Hardneſ

VII. We have uſed figures to denote the comparative HARDNESS of bodies; for an explanation of which, we refer to the article CHEMISTRY, Vol. I. p. 224. of this *Supplement*.

12 Ductility and brittleneſs.

VIII. With reſpect to DUCTILITY and BRITTLENESS, minerals are either *malleable*; *ſectile*, capable of being cut without breaking, but not malleable; *flexile*, capable of being bent, and when bent retaining their ſhape; or *elaſtic*, capable of being bent, but recovering their former ſhape Minerals deſtitute of theſe properties are *brittle*. Brittle minerals, with reſpect to the eaſe with which they may be broken, are either *very tough*, *tough*, *fragile*, or *very fragile*.

13 Fracture.

IX. By FRACTURE is meant the freſh ſurface which a mineral diſplays when broken. It is either *flat*, without any general elevation or depreſſion; or *conchoidal*, having wide extended roundiſh hollows and gentle riſings. When theſe are not *very* evident, the fracture is called *flat* conchoidal; when they are ſmall, it is called *ſmall* conchoidal; and when of great extent, *great* conchoidal.

The fracture may alſo be *even*, free from all aſperities; *uneven*, having many ſmall, ſharp, abrupt, irregular elevations and inequalities; and from the ſize of theſe, this fracture is denominated *coarſe*, *ſmall*, or *fine*; *ſplintery*, having ſmall, thin, half detached, ſharp edged ſplinters, according to the ſize of which this fracture is denominated *coarſe* or *fine*; or *rugged*, having many very minute ſharp hooks, more ſenſible to the hand than the eye.

14 Texture.

X. By TEXTURE is meant the internal ſtructure or diſpoſition of the matter of which a mineral is compoſed, which may be diſcovered by breaking it. The texture is either *compact*, without any diſtinguiſhable parts, or the appearance of being compoſed of ſmaller parts; *earthy*, compoſed of very minute *almoſt* imperceptible rough parts; *granular*, compoſed of ſmall ſhapeleſs grains; *globuliform*, compoſed of ſmall ſpherical bodies; *fibrous*, compoſed of fibres which may be *long*, *ſhort*, *ſtraight*, *crooked*, *parallel*, *divergent*, *ſtellated*, *faſciculated*, or *decuſſated*; *radiated*, conſiſting of long narrow flattiſh lamellæ; or *lamellar* or *foliated*, conſiſting of ſmooth continued plates covering each other: theſe plates may be either *ſtraight*, *crooked*, or *undulating*. Extern Charact

XI. The STRUCTURE OR COMPOUND TEXTURE is the manner in which the parts that form the texture are diſpoſed. It is either *ſlaty*, in ſtraight layers like ſlate; *teſtaceous*, in incurvated layers; *concentric*, in concentric layers; or *columnar*, in columns. 15 Structu

The *texture* and *ſtructure* may at firſt view appear the ſame; but in reality they are very different. Thus common ſlate has often the *ſlaty ſtructure* and *earthy texture*. The texture of pitcoal is compact, but its ſtructure is often ſlaty.

XII. By FRAGMENTS is meant the ſhape of the pieces into which a mineral breaks when ſtruck with a hammer. They are either *cubic*; *rhomboidal*; *wedgeſhaped*; *ſplintery*, thin, long, and pointed; *tabular*, thin, and broad, and ſharp at the corners, as common ſlate; or *indeterminate*, without any particular reſemblance to any other body. The *edges* of indeterminate fragments are either *very ſharp*, *ſharp*, *ſharpiſh*, or *blunt*. 16 Fragme

XIII. By the FEEL of minerals is meant the ſenſation which their ſurfaces communicate when handled. The feel of ſome minerals is *greaſy*, of others *dry*, &c. 17 Feel.

XIV. Some minerals when ſtruck give a *clear* SOUND, as common ſlate; others a *dull* ſound. 18 Sound

The SMELL, TASTE, SPECIFIC GRAVITY, and MAGNETISM of minerals, require no explanation.

With reſpect to ELECTRICITY, ſome minerals become electric when *heated*, others when *rubbed*, others cannot be rendered electric. The electricity of ſome minerals is *poſitive* or *vitreous*, of others *negative* or *reſinous*.

As for the CHEMICAL properties of minerals, they have been already explained in the article CHEMISTRY, which makes a part of this *Supplement*. And for the deſcription of the blow-pipe, and the manner of uſing it, we refer the reader to a treatiſe on that ſubject prefixed to the article MINERALOGY in the *Encyclopædia*.

CHAP. II. OF THE ARRANGEMENT OF MINERALS.

MINERALS may be arranged two ways, according to their external characters, and according to their chemical compoſition. The firſt of theſe methods has been called an *artificial* claſſification; the ſecond, a *natural* one. The firſt is indiſpenſably neceſſary for the ſtudent of nature; the ſecond is no leſs indiſpenſable for the proficient who means to turn his knowledge to account. Without the firſt, it is impoſſible to diſcover the *names* of minerals; and without the ſecond, we muſt remain ignorant of their uſe.

Almoſt every ſyſtem of mineralogy hitherto publiſhed, at leaſt ſince the appearance of Werner's *external characters*, has attempted to combine theſe two arrangements, and to obtain at one and the ſame time the advantages peculiar to each. But no attempt of this kind has hitherto ſucceeded. Whether this be owing to any thing impoſſible in the undertaking, or to the preſent

(c) Theſe four degrees have been denoted by Kirwan by the figures 4, 3, 2, 1, and no luſtre by 0. We have imitated him in the preſent article.

Artificial System. present imperfect state of mineralogy, as is more probable, we do not take upon us to determine. But surely the want of success which has hitherto attended all attempts to combine the two arrangements, ought to suggest the propriety of separating them. By adhering strictly to one language, the trouble of studying two different systems would be entirely prevented. They would throw mutual light upon each other: the artificial system would enable the student to discover the *names* of minerals; the natural would enable him to arrange them, and to study their properties and uses.

The happy arrangement of Cronstedt, together with the subsequent improvements of Bergman, Werner, Kirwan, Hauy, and other celebrated mineralogists, has brought the *natural* system of mineralogy to a considerable degree of perfection. But an *artificial* system is still a desideratum; for excepting Linnæus, whose success was precluded by the state of the science, no one has hitherto attempted it. Though we are very far from thinking ourselves sufficiently qualified for undertaking such a task, we shall nevertheless venture, in the next chapter, to sketch out the rudiments of an artificial system. The attempt, at least, will be laudable, even though we should fail.

Chap. III. Artificial System.

19 Artificial classes. Minerals may be divided into six classes:

1. Minerals that cannot be fused by the blow-pipe *per se*.
2. Minerals fusible *per se* by the blow-pipe.
3. Minerals fusible by the blow-pipe *per se* when exposed to the blue flame, but not when exposed to the yellow flame.
4. Minerals fusible *per se* by the blow-pipe; and when in fusion, partly evaporating in a visible smoke.
5. Minerals which totally evaporate before the blow-pipe.
6. Minerals totally soluble in muriatic acid with effervescence, the solution colourless.

Under these heads we shall arrange the subjects of the mineral kingdom.

Class I. INFUSIBLE.

ORDER I. Specific gravity from 16 to 12.
Genus I. Colour whitish iron grey.
Species 1. Native platinum.

ORDER II. Sp. gr. 8.5844 to 7.006.
Genus I. Attracted by the magnet.
Sp. 1. Native iron.
Genus II. Not attracted by the magnet.
Sp. 1. Native copper.
Flexible and malleable. Colour usually red.
Wolfram.
Brittle. Colour usually brown or black.

ORDER III. Sp. gr. from 6.4509 to 5.8.
Genus I. Forms a blue glass with microcosmic salt, which becomes colourless in the yellow, but recovers its colour in the blue flame.
Sp. 1. Tungstat of lime.
Genus II. Forms with microcosmic salt a permanently coloured bead.
Sp. 1. Sulphuret of cobalt.

ORDER IV. Sp. gr. from 4.8 to 4.5.
Genus I. Tinges borax dark green.
Sp. 1. Common magnetic iron stone.
Genus II. Tinges borax reddish brown.
Sp. 1. Grey ore of manganese.

ORDER V. Sp. gr. from 4.4165 to 3.292. Infusible with fixed alkalies.
Genus I. Hardness 20.
Sp. 1. Diamond.
Genus II. Hardness 15 to 17. Causes single refraction.
Sp. 1. Telesia.
Sp. 2. Corundum.
Genus III. Hardness 13. Single refraction.
Sp. 1. Ruby.
Crystallizes in octohedrons.
Genus IV. Hardness 12. Single refraction.
Sp. 1. Chrysoberyl.
Genus V. Hardness 12. Causes double refraction. Becomes electric when heated.
Sp. 1. Topaz.
Genus VI. Hardness 10 to 16. Double refraction. Sp. gr. 4.2 to 4.165.
Sp. 1. Zircon.
Genus VII. Hardness 6 to 9. Feels greasy.
Sp. 1. Cyanite.
Genus VIII. Hardness 9 to 10. Feel not greasy. Double refraction. Sp. gr. 3.283 to 3.285.
Sp. 1. Chrysolite.
Genus IX. Hardness 12. Infusible with borax. Colour of large masses black, of thin pieces deep green.
Sp. Ceylanite.
(*Phosphat of lime.*)

ORDER VI. Sp. gr. from 2.9829 to 1.987. Infusible with fixed alkalies.
Genus I. Hardness 12.
Sp. 1. Emerald.
Genus II. Hardness 10.
Sp. 1. Jade.
Genus III. Hardness 6 to 7. Somewhat transparent.
Sp. 1. Phosphat of lime.
Before the blow-pipe becomes surrounded with a luminous green vapour.
Genus IV. Hardness 6. Opaque.
Sp. 1. Micarelle.
Genus V. Stains the fingers. Colour lead grey.
Sp. 1. Plumbago.
Spanish wax rubbed with plumbago does not become electric; or if it does, the electricity is negative. Streak lead grey even on earthen ware.

ORDER VII. Sp. gr. from 4.7385 to 4.569. Fusible with fixed alkalies.
Genus I. Stains the fingers. Colour lead grey.
Sp. 1 Molybdena.
Spanish wax rubbed with molybdena becomes positively electric. Streak on earthen ware yellowish green.

ORDER VIII. Sp. gr. from 4.1668 to 2.479. Fusible with fixed alkalies.
* Hardness from 10 to 12.

Artificial System.

GENUS I. Usually white. Crystals dodecahedrons. Double refraction. Fracture imperfectly conchoidal or splintery. Brittle.

Sp. 1. Quartz.

GENUS II. Usually dark brown. Fracture perfectly conchoidal. Brittle. Easily breaks into splinters.

Sp. 1. Flint.

GENUS III. Not brittle. Fracture even or imperfectly conchoidal.

Sp. 1. Chalcedony.

Sp. 2. Jasper.

GENUS IV. Forms with potass a violet glass, with soda or borax a brown glass, with microcosmic salt a honey yellow glass. Colour green. Amorphous.

Sp. 1. Chrysoprasium.

GENUS V. Tinges soda red. The colour disappears before the blue flame, and returns before the yellow flame.

Sp. 1. Oxyd of manganese and barytes.

Sp. 2. Black ore of manganese.

Sp. 3. Carbonat of manganese.

(Brown ore of iron. Red ore of iron.)

** Hardness 9 to 3.

GENUS VI. Flexible and elastic in every direction.

Sp. 1. Elastic quartz.

GENUS VII. Emits white flakes before the blowpipe.

Sp. 1. Blende.

GENUS VIII. Becomes electric when heated.

Sp. 1. Calamine.

GENUS IX. Tinges borax green. Blackens before the blow-pipe.

Sp. 1. Mountain blue.
Colour blue.

Sp. 2. Green carbonat of copper.
Colour green.

GENUS X. Tinges borax green. Becomes attractable by the magnet by the action of the blow-pipe.

Sp. 1. Brown iron ore.
Colour brown.

Sp. 2. Red iron ore.
Colour red.

GENUS XI. Tinges borax smutty yellow. Becomes brownish black before the blow-pipe.

Sp. 1. Carbonat of iron.

GENUS XII. Feels greasy.

Sp. 1. Steatites.

(Black ore of Manganese. Carbonat of manganese. Mica.)

ORDER IX. Sp. gr. from 2.39 to 1.7.

GENUS I. Lustre glassy.

Sp. 1. Opal.

Sp. 2. Hyalite.

GENUS II. Lustre greasy.

Sp. 1. Pitchstone.

GENUS III. Lustre waxy or pearly.

Sp. 1. Staurolite.

CLASS II. FUSIBLE.

ORDER I. Sp. gr. from 19 to 10.

GENUS I. Colour Yellow.

Sp. 1 Native gold.

GENUS II Colour white.

Sp. 1. Native Silver.

GENUS III. Colour yellowish white.

Sp. 1. Alloy of silver and gold.

ORDER II. Sp. gr. from 7.786 to 4.5.

GENUS I Flexible and malleable.

Sp. 1. Sulphuret of silver.

** Brittle.

GENUS II. Tinges borax white.

Sp. 1. Tinstone.

GENUS III. Tinges borax green.

Sp. 1. Sulphuret of copper.
Colour bluish grey.

Sp. 2. Chromat of lead.
Colour aurora red.

Sp. 3. Purple copper ore.
Colour purple.

GENUS IV. Tinges borax faint yellow. Becomes black when exposed to the vapour of sulphuret of ammonia.

Sp. 1. Galena.
Colour bluish grey. Lustre metallic. Fragments cubic.

Sp. 2. Black lead ore.
Colour black. Lustre metallic.

Sp. 3. Lead ochre.
Colour yellow, grey, or red. Lustre o.

Sp. 4. Carbonat of lead.
Colour white. Lustre waxy.

Sp. 5. Phosphat of lead.
Usually green. Lustre waxy. After fusion by the blow-pipe crystallizes on cooling.

Sp. 6. Molybdat of lead.
Colour yellow. Streak white. Lustre waxy.

ORDER III. Sp. gr. from 4.35 to 3.

* Hardness 14 to 9.

GENUS I. Melts without frothing into a grey enamel.

Sp. 1. Garnet.
Colour red.

GENUS II. Melts into a brownish enamel.

Sp. 1. Shorl.
Colour black. Opaque.

GENUS III. Froths and melts into a white enamel.

Sp. 1. Tourmaline.
Becomes electric by heat.

GENUS IV. Froths and melts into a greenish black enamel.

Sp. 1. Basaltine.

GENUS V. Froths amd melts into a black enamel.

Sp. 1. Thallite.
Colour dark green.

Sp. 2. Thumerstone.
Colour clove brown.

** Hardness 5 to 8.

GENUS VI. Melts into a transparent glass.

Sp. 1. Fluat of lime.
Powder phosphoresces when thrown on a hot iron.

GENUS VII. Melts into a black glass.

Sp. 1.

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Sp. 1. Hornblende.

GENUS VIII. Melts into a black bead with a sulphureous smell, and deposits a blue oxyd on the charcoal.

Sp. 1. Sulphuret of tin.

GENUS IX. Melts into a brown glass. Tinges borax violet.

Sp. 1. Asbestoid.

Colour green.

GENUS X. Melts into a brown (?) glass. When fused with potass, and dissolved in water, the solution becomes of a fine orange yellow.

Sp. 1. Chromat of iron.

GENUS XI. Before the blow-pipe yields a bead of copper.

Sp. 1. Red oxyd of copper.

(Sulphuret of copper.)

ORDER IV. Sp. gr. from 2.945 to 2.437.

GENUS I. Composed of scales.

Sp. 1. Talk.

Feels greasy. Spanish wax rubbed by it becomes positively electric.

GENUS II. Composed of thin plates, easily separable from each other.

Sp. 1. Mica.

Plates flexible and elastic, may be torn but not broken. Spanish wax rubbed by it becomes negatively electric.

Sp. 2. Stilbite.

Plates somewhat flexible. Colour pearl white. Powder renders syrup of violets green. Froths and melts into an opaque white enamel.

Sp. 3. Lepidolite.

Colour violet. Powder white with a tint of red. Froths and melts into a white semitransparent enamel full of bubbles.

GENUS III. Texture foliated.

Sp. 1. Felspar.

Fragments rhomboidal. Hardness 9 to 10.

Sp. 2. Leucite.

Always crystallized. White. Powder renders syrup of violets green. Hardness 8 to 10.

Sp. 3. Argentine felspar.

Always crystallized. Two faces dead white, two silvery white.

Sp. 4. Prehnite.

Colour green. Froths and melts into a brown enamel.

GENUS IV. Texture fibrous. Fibres easily separated.

Sp. 1. Asbestus.

Feels somewhat greasy.

GENUS V. Texture striated.

Sp. 1. Ædelite.

Absorbs water. Froths and melts into a frothy mass.

GENUS VI. Texture earthy or compact.

Sp. 1. Lazulite.

Froths and melts into a yellowish black mass. If previously calcined, gelatinizes with acids.

Sp. 2. Borat of lime.

Tinges the flame greenish, froths and melts into a yellowish enamel garnished with small projecting points. If the blast be continued, these dart off in sparks.

ORDER V. Sp. gr. from 2.348 to 0.68.

GENUS I. Hardness 10.

Sp. 1. Obsidian.

Colour blackish, in thin pieces green.

GENUS II. Hardness 6 to 8.

Sp. 1. Zeolite.

Gelatinizes with acids. Becomes electric by heat.

GENUS III. Hardness 3 to 4.

Sp. 1. Amianthus.

Feels greasy. Texture fibrous.

Sp. 2. Mountain cork.

Elastic like cork.

CLASS III. FUSIBLE BY THE BLUE FLAME, INFUSIBLE BY THE YELLOW.

GENUS I. Sp. gr. from 4.43 to 4.4.

Sp. 1. Sulphat of barytes.

GENUS II. Sp. gr. from 3.96 to 3.51.

Sp. 1. Sulphat of strontites.

GENUS III. Sp. gr. from 2.311 to 2.167.

Sp. 1. Sulphat of lime.

CLASS IV. FUSIBLE, AND PARTLY EVAPORATING.

ORDER I. Sp. gr. from 10 to 5.

GENUS I. Colour white or grey. Lustre metallic.

* Sp. gr. 9 to 10.

Sp. 1. Native amalgam.

Tinges gold white. Creaks when cut.

Sp. 2. Alloy of silver and antimony.

Powder greyish black.

** Sp. gr. from 6.467 to 5.309.

Sp. 3. Sulphuret of bismuth.

Melts when held to the flame of a candle.

Sp. 4. Dull grey cobalt ore.

Streak bluish grey. Hardness 10. When struck, emits an arsenical smell. Lustre scarcely metallic.

GENUS II. Colour red, at least of the streak.

Sp. 1. Red silver ore.

Burns with a blue flame.

Sp. 2. Hepatic mercurial ore.

Does not flame, but gives out mercury before the blow-pipe.

GENUS III. Colour blue.

Sp. 1. Blue lead ore.

Burns with a blue flame and sulphureous smell, and leaves a button of lead.

GENUS IV. Colour yellowish green.

Sp. 1. Phosphat and arseniat of lead combined.

When fused by the blow-pipe, crystallizes on cooling.

GENUS V. Colour usually that of copper. So

Artificial System.

gr. 6.608 ; to 6.6481.

Sp. Sulphuret of nickel.

Exhales before the blow-pipe an arsenical smoke.

ORDER II. Sp. gr. from 4.6 to 3.44.

GENUS I. Colour grey.

Sp. 1. Grey ore of antimony.

Burns with a blue flame, and leaves a white oxyd.

Sp. 2. Grey copper ore.

Crackles before the blow-pipe.

GENUS II. Colour yellow.

Sp. 1. Pyrites.

Burns with a blue flame and sulphureous smell, and leaves a brownish bead.

Sp. 2. Yellow copper ore.

Melts into a black mass.

CLASS V. EVAPORATING.

ORDER I. Sp gr. 13.6.

GENUS I. Fluid.

Sp. 1. Native mercury.

ORDER II. Sp. gr. from 10 to 5.419.

GENUS I. Colour red.

Sp. 1. Native cinnabar.

GENUS II. Colour white or grey. Lustre metallic.

Sp. 1. Native bismuth.

Melts into a white bead, and then evaporates in a yellowish white smoke. Sp. gr. 9 to 9.5.

Sp. 2. Native antimony.

Melts and evaporates in a grey smoke. Sp. gr. 6.6 to 6.8.

Sp. 3. Native arsenic.

Evaporates without melting, and gives out a garlic smell.

ORDER III. Sp. gr. from 4.8 to 3.33.

GENUS I. Colour red.

Sp. 1. Red antimonial ore.

Melts with a sulphureous smell. Sp. gr. 4.7.

Sp. 2. Realgar.

Melts with a garlic smell. Sp. gr. 3.384.

GENUS II. Colour yellow.

Sp. 1. Orpiment.

CLASS VI. SOLUBLE WITH EFFERVESCENCE IN MURIATIC ACID.

GENUS I. Sp. gr. from 4.338 to 4.3.

Sp. 1. Carbonat of barytes.

GENUS II. Sp. gr. from 3.66 to 3.4.

Sp. 1. Carbonat of strontites.

GENUS III. Sp. gr. from 2.8 to 1 or under.

Sp. 1. Carbonat of lime.

We have purposely avoided giving names to the classes, orders, and genera; because a more careful examination will doubtless suggest many improvements in the arrangement, and an artificial system ought to be brought to a great degree of perfection before its classes, orders, and genera, be finally settled.

We have excluded from this arrangement all those bodies which in the following system are arranged under the class of combustibles; because there can scarcely be any difficulty in distinguishing them both from the other classes and from one another. For similar reasons we have excluded the class of salts.

CHAP. IV. NATURAL SYSTEM.

Avicenna, a writer of the 11th century, divided minerals into four classes; stones, salts, inflammable bodies, and metals (D). This division has been, in some measure, followed by all succeeding writers. Linnæus, indeed, the first of the moderns who published a system of mineralogy, being guided by the external characters alone, divided minerals into three classes, *petræ, mineræ, fossilia*: but Avicenna's classes appear among his orders. The same remark may be made with respect to the systems of Wallerius, Wolsterdorf, Cartheuser, and Justi, which appeared in succession after the first publication of Linnæus's *Systema Naturæ*, in 1736. At last, in 1758, the system of Cronstedt appeared. He reinstated the classes of Avicenna in their place; and his system was adopted by Bergman, Kirwan, Werner, and the most celebrated mineralogists who have written since. We also shall adopt his classes, with a few slight exceptions; because we are not acquainted with any other division which is intitled to a preference.

20 Natural classes.

We shall therefore divide this treatise into four classes. I. Stones. II. Salts. III. Combustibles. IV. Ores.

The first class comprehends all the minerals which are composed chiefly or entirely of earths; the second, all the combinations of acids and alkalies which occur in the mineral kingdom; the third, those minerals which are capable of combustion, and which consist chiefly of sulphur, carbon, and oil; the fourth, the mineral bodies which are composed chiefly of metals.

CLASS I. EARTHS AND STONES.

WE shall divide this class into three orders. The first order shall comprehend all chemical combinations of earths with each other; the second order, chemical combinations of earths with acids; and the third order, mechanical mixtures of earths or stones. All the minerals belonging to the first order exhibit the same homogeneous appearance to the eye as if they were simple bodies. We shall therefore, for want of a better name, call the first order *simple*; the second order we shall distinguish by the epithet of *saline*; and the third we shall

(D) Corpora mineralia in quatuor species dividuntur, scilicet in lapides, et in liquefactiva, sulphurea, et sales. Et horum quædam sunt raræ substantiæ et debilis compositionis, et quædam fortis substantiæ, et quædam ductibilia, et quædam non. *Avicenna de congelatione et conglutinatione lapidum*, Cap. 3. *Theatrum Chemicum*, p. 997.

Earths and Stones. call *aggregates;* because most of the minerals belonging to it consist of various *simple stones*, cemented, as it were, together.

Order I. SIMPLE STONES.

21 Cronstedt's genera. Cronstedt divided this order into nine genera, corresponding to nine earths; one of which he thought composed the stones arranged under each genus. The names of his genera were, *calcareæ*, *siliceæ*, *granatinæ*, *argillaceæ*, *micaceæ*, *fluores*, *asbestinæ*, *zeolithicæ*, *magnesiæ*. All his earths were afterwards found to be compounds, except the first, second, fourth, and ninth. Bergman, 22 Improved. therefore, in his Sciagraphia, first published in 1782, reduced the number of genera to five; which was the number of primitive earths known when he wrote. Since that period three new earths have been discovered. Accordingly, in the latest systems of mineralogy, the genera belonging to this order amount to eight. Each genus is named from an earth; and they are arranged in the newest Wernerian system, which we have seen, as follows:

1. Jargon genus.	5. Magnesian genus.
2. Siliceous genus.	6. Calcareous genus.
3. Glucina genus.	7. Barytic genus.
4. Argillaceous genus.	8. Strontian genus.

Mr Kirwan, in his very valuable system of mineralogy, has adopted the same genera. Under each genus, those stones are placed, which are composed chiefly of the earth which gives a name to the genus, or which at least are supposed to possess the characters which di-23 Still deficient. stinguish that earth.

A little consideration will be sufficient to discover that there is no natural foundation for these genera. Most stones are composed of two, three, or even four ingredients; and, in many cases, the proportion of two or more of these is nearly equal. Now, under what genus soever such minerals are arranged, the earth which gives it a name must form the smallest part of their composition. Accordingly, it has not been so much the chemical composition, as the external character, which has guided the mineralogist in the distribution of his species. The genera cannot be said properly to have any character at all, nor the species to be connected by any thing else than an arbitrary title. This defect, which must be apparent in the most valuable systems of mineralogy, seems to have arisen chiefly from an attempt to combine together an artificial and natural system. As we have separated these two from each other, it becomes necessary for us to attend more accurately to the natural distribution of genera than has hitherto been done. We have accordingly ventured to form new genera for this order, and we have formed them according 24 New genera. to the following rules.

The only substances which enter into the minerals belonging to this order, in such quantity as to deserve attention, are the following:

Alumina,	Glucina,
Silica,	Zirconia,
Magnesia,	Oxyd of iron,
Lime,	Oxyd of chromum,
Barytes,	Potass,

Simple Stones. All those minerals which are composed of the *same* ingredients we arrange under the *same* genus. According to this plan, there must be as many genera as there are varieties of combinations of the above substances existing in nature. The varieties in the *proportion* of the ingredients constitute species. We have not imposed names upon our genera, but, in imitation of Bergman*, have denoted each by a symbol. This symbol is composed of the first letter of every substance which enters in any considerable quantity into the composition of the minerals arranged under the genus denoted by it. Thus, suppose the minerals of a genus to be composed of *alumina*, *silica*, and *oxyd of iron*, we denote the genus by the symbol *asi*. The letters are arranged according to the proportion of the ingredients; that which enters in the greatest proportion being put first, and the others in their order. Thus the genus *asi* is composed of a considerable proportion of alumina, of a smaller proportion of silica, and contains least of all of iron. By this contrivance, the symbol of a genus contains, within the compass of a few letters, a pretty accurate description of its nature and character. Where the proportions of the ingredients vary in the same genus so much, that the letters which constitute its symbol change their place, we subdivide the genus into parts; and whenever the minerals belonging to any genus become too numerous, advantage may be taken of these subdivisions, and each of them may be formed into a separate genus. At present this seems unnecessary (E).

* Opusc. iv. 231.

The following is a view of the different genera belonging to this order, denoted each by its symbol. Every genus is followed by the species included under it; and the whole are in the order which we mean to follow in describing them:

I. A.
- Telesia,
- Corundum,
- Native alumina.

II. AMC.
- Ruby.

III. AIM.
- Ceylanite,

IV. S.
- Quartz,
- Elastic quartz,
- Flint,
- Opal,
- Pitchstone,
- Chrysoprasium.

V. 1. AS.
- Topaz,
- Sommite,
- Shorlite.

2. SA.
- Rubellite,
- Hornslate,
- Hornstone,
- Chalcedony,
- Jasper,
- Tripoli.

VI. 1. ASI.
- Micarell,
- Shorl,
- Granatite,

2. SAI.
- Tourmaline,
- Argentine felspar,
- Mica,
- Talc,
- Basaltine,
- Hornblende,
- Obsidian,
- Petrilite,
- Felsite.

VII. SAP.
- Felspar,
- Lepidolite,
- Leucite.

VIII. SAG.
- Emerald.

IX. SAB.
- Staurolite.

X. 1. ASL.
- Chrysoberyl.

2. SAL.
- Hyalite,
- Ædelite.

(E) We need hardly remark, that the last three genera of Werner belong to the second order of the first class of this treatise.

3. SAWL.
Zeolite,
Stilbite,
Analcime.
4. SLA.
Lazulite.
XI. SALI.
Garnet,
Thumerftone,
Prehnite,
Thallite.
XII. 1. AMS.
Cyanite.
2. MSA.
Serpentine.
XIII. MSAI.
Potftone,
Chlorite.
XIV. SLAM.
Siliceous fpar.
XV. SAMLI.
Argillite.
XVI. SM.
Kiffekill,
Steatites.
XVII. MSI.
Chryfolite,
Jade.
XVIII. SML.
Afbeftus,
Afbeftinite.
XIX. 1. SILM.
Pyroxen,
Afbeftoid.
2. SMIL.
Actinolite.
XX. SL.
Shiftofe hornftone.
XXI. ZS.
Zircon.

G. I. A. Telefia.

GENUS I. A.

SPECIES 1. Telefia (F).

Oriental ruby, fapphire, and *topaz* of mineralogifts.—*Rubis d'orient* of De Lifle.

Three ftones, diftinguifhed from each other by their colour, have long been held in high eftimation on account of their hardnefs and beauty. Thefe ftones were known among lapidaries by the names of *ruby, fapphire*, and *topaz*, and the epithet *oriental* was ufually added, to diftinguifh them from other three, known by the fame names and the fame colours, but very inferior in hardnefs and beauty. Mineralogifts were accuftomed to confider thefe ftones as three diftinct fpecies, till Romé de Lifle obferved that they agreed in the form of their cryftals, their hardnefs, and moft of their other properties. Thefe obfervations were fufficient to conftitute them one fpecies; and accordingly they were made one fpecies by Romé de Lifle himfelf, by Kirwan, and feveral other modern mineralogical writers. But this fpecies was deftitute of a proper name, till Mr Hauy, whofe labours, diftinguifhed equally by their ingenuity and accuracy, have contributed not a little to the progrefs of mineralogy, denominated it *telefia*, from the Greek word τελεσια, which fignifies *perfect*.

The telefia is found in the Eaft Indies, efpecially in Pegu and the ifland of Ceylon; and it is moft commonly cryftallized. The cryftals are of no great fize; Their *primitive* form, according to Mr Hauy, is a regular fix-fided prifm, divifible in directions parallel both to its bafes and its fides; and confequently giving for the form of its primitive nucleus, or of its *integrant molecule*, an equilateral three fided prifm *. The moft ufual variety is a dodecahedron, in which the telefia appears under the form of two very long flender fix-fided pyramids, joined bafe to bafe †. The fides of thefe pyramids are ifofceles triangles, having the angle at their vertex 22° 54', and each of thofe at the bafe 78° 48' (G). The inclination of a fide of one pyramid to a contiguous fide of the other pyramid is 139° 54' †. In fome fpecimens the fummits of the pyramids are wanting, fo that the cryftal has the appearance of a fix fided prifm, fomewhat thicker in the middle than towards the extremities *. The three alternate angles at each extremity of this prifm are alfo fometimes wanting, and a fmall triangular face inftead of them, which renders the bafes of the fuppofed prifm nine-fided. The inclination of each of thefe fmall triangles to the bafe is 122° 18' ‡ For figures of thefe cryftals we refer the reader to Romé de Lifle and Hauy *.

* Ann de Chim. xvii. 313.
† Plate XXXVI. fig. 1.
Simple Stones.
† Ibid and Romé de Lifle, ii. 315.
* Fig. 2.
‡ Hauy, ibid.
* Ibid.

The texture of the telefia is foliated, and the joints are parallel to the bafe of the prifm †. Its luftre varies from 3 to 4 (H). Tranfparency ufually 3 or 4, fometimes only 2. It caufes only a fingle refraction. Specific gravity from 4. to 4.288. Hardnefs from 15 to 17. It is either colourlefs, or red, yellow or blue. Thefe colours have induced lapidaries to divide the telefia into the three following varieties.

† Hauy.

Variety 1. Red telefia.

Oriental ruby.

Colour carmine red, fometimes verging towards violet. Sometimes various colours appear in the fame ftone, as red and white, red and blue, orange red. Hardnefs 17. Sp. gr. 4.288.

Variety 2. Yellow telefia.

Oriental topaz.

Colour golden yellow. Tranfp. 4. Hardnefs 15. Sp. gr. 4.0106.

Variety 3. Blue telefia.

Oriental fapphyr.

Colour Berlin blue, often fo very faint that the ftone appears almoft colourlefs. Tranfp. 3, 4, 2. Hardnefs 17. Sp. gr. 3.991 to 4.083 ‡. This variety is not probably the fame with the fapphyr of the ancients. Their fapphyr was diftinguifhed by gold-coloured fpots, none of which are to be feen in the fapphyr of the moderns ||.

‡ Greville, Nicholfon's Jour. iii. 11.
|| Hill's Theophraftus, περι των λιθων, p. 100.

A fpecimen of this laft variety, analyfed by Mr Klaproth, was found to contain in 100 parts,

98.5 alumina,
1.0 oxyd of iron,
0.5 lime,

100.0 *.

* Beiträge, i. 81.

The colouring matter of all thefe varieties is, according to Bergman's experiments, iron, in different ftates of oxydation. He found that the topaz contained .06, the ruby .1, and the fapphyr .02 of that metal †. But when thefe experiments were made, the analyfis of ftones was not arrived at a fufficient degree of perfection to enfure accuracy. No conclufion, therefore, can be drawn from thefe experiments, even though we were certain that they were made upon the real varieties of telefia.

† Bergman, ii. 96.

SPECIES

(F) See *Kirwan's Mineralogy*, I. 250.—*Gmelin's Syftema Naturæ of Linnæus*, III. 170.—*Romé de Lifle's Cryftallographie*, II. 212.—*Bergmanni Opufcula*, II. 72.

(G) In fome inftances, the angle at the vertex is 31°, thofe at the bafe 74° 30', and the inclination of two triangles 122° 36'. See *Hauy, ibid.*

(H) When the *kind* of luftre is not fpecified, as in the prefent inftance, the *common* is always meant.

Earths and Stones.

26 Corundum.

SPECIES 2. Corundum (I).

Corundum of Gmelin—*Adamantine spar* of Klaproth and Kirwan—*Corindon* of Hauy—*Corivindum* of Woodward.

This stone, though it appears to have been known to Mr Woodward, may be said to have been first distinguished from other minerals by Dr Black. In 1768, Mr Berry, a lapidary in Edinburgh, received a box of it from Dr Anderson of Madras. Dr Black ascertained, that these specimens differed from all the stones known to Europeans; and, in consequence of its hardness, it obtained the name of *adamantine spar*. Notwithstanding this, it could scarcely be said to have been known to European mineralogists till Mr Greville of London, who has done so much to promote the science of mineralogy, obtained specimens of it, in 1784, from India, and distributed them among the most eminent chemists, in order to be analysed. Mr Greville also learned, that its Indian name was Corundum. It is found in Indostan, not far from the river Cavery, which is south from Madras, in a rocky matrix, of considerable hardness, partaking of the nature of the stone itself *. It occurs also in China; and a substance, not unlike the matrix of corundum, has been found in Teree, one of the western islands of Scotland †.

* Garrow and Greville, *Nicholson's Jour.* ii. 540.

The corundum is usually crystallized. Its primitive form, discovered by Mr Hauy ‡ and the Count de Bournon *, is a rhomboidal parallelopiped, whose sides are equal rhombs, with angles of 86° and 94°, according to Bournon, or whose diagonals are to each other as $\sqrt{17}$ to $\sqrt{15}$, according to Hauy; which is very nearly the same thing †. The most common variety, for the primitive form has never yet been found, is the regular six-sided prism, the alternate angles of which are sometimes wanting ||, and the triangular faces, which occupy their place, are inclined to the base at an angle of 122° 34′ ‡. Sometimes the corundum is crystallized in the form of a six-sided pyramid, the apex of which is generally wanting. For a description and figure of these, and all the other varieties of corundum hitherto observed, we refer the reader to the dissertation of the Count de Bournon on the subject *.

† Greville, *ibid.*
‡ *Jour. de Min.* N° xxviii. 262.
* *Nicholson's Jour.* ii. 541.
† Fig. 3.
|| Fig. 4.
‡ *De Bournon.*
* See also *Hauy. Jour. de Min.* N° xxviii. 262.

The texture of the corundum is foliated, and the natural joints are parallel to the faces of the primitive rhomboidal parallelopiped. Lustre, when in the direction of the laminæ, 3; when broken across, 0. Opake, except when in very thin pieces. Hardness 15. Sp. gr. from 3.710 to 4.180 †. Colour grey, often with various shades of blue and green.

† *Klaproth.* See also *Mr Greville, Nicholson's Jour.* iii 11.

According to the analysis of Klaproth, the corundum of India is composed of

89.5	alumina,
5.5	silica,
1.25	oxyd of iron,
96.25 ‡.	

‡ *Beiträge* i. 77.

A specimen from China of

84.0	alumina,
6.5	silica,
7.5	oxyd of iron,
98.0 ||.	

|| *Ibid.* i 73.

Notwithstanding the quantity of silica and of iron which these analyses exhibit in the corundum, we have been induced to include it in the present genus, on account of the strong resemblance between it and the third variety of telesia. The striking resemblance between the crystals of telesia and corundum will appear evident, even from the superficial description which we have given; and the observations of De Bournon * render this resemblance still more striking. It is not improbable, therefore, as Mr Greville and the Count de Bournon have suggested, that corundum may be only a variety of telesia, and that the seeming difference in their ingredients is owing to the impurity of those specimens of corundum which have hitherto been brought to Europe. Let not the difference which has been found in the primitive form of these stones be considered as an insuperable objection, till the subject has been again examined with this precise object in view; for nothing is easier than to commit an oversight in such difficult examinations.

* *Nichol. Jour.* ii. 9.

27 Native alumina.

SPECIES 3. Native alumina (K).

This substance has been found at Halles in Saxony in compact kidney-form masses. Its consistence is earthy. Lustre 0. Opaque. Hardness 4. Brittle. Sp. gr. moderate. Feels soft, but meagre. Adheres very slightly to the tongue. Stains very slightly. Colour pure white. Does not readily diffuse itself in water.

It consists of pure alumina, mixed with a small quantity of carbonat of lime, and sometimes of sulphat of lime †.

G. II. AMC Ruby.

GENUS II. AMC.

SPECIES 1. Ruby (L).

Spinel and *balass Ruby* of Kirwan—*Ruby* of Hauy—*Rubis spinelle octoedre* of De Lisle—*Spinellus* of Gmelin.

This stone, which comes from the island of Ceylon, is usually crystallized. The primitive form of its crystals is a regular octohedron, composed of two four-sided pyramids applied base to base, each of the sides of which is an equilateral triangle ‡ (M). In some cases two opposite sides of the pyramids are broader than the other two; and sometimes the edges of the octohedron are wanting, and narrow faces in their place. For figures and descriptions of these, and other varieties of these crystals, we refer the reader to *Romé de Lisle* and the *Abbé Estner* *.

‡ Fig. 5.

The texture of the ruby is foliated. Its lustre is 3. Transp. 3.4. It causes a single refraction. Hardness 13. Sp. gr. 3.570 † to 3.625 †. Colour red: if deep, the ruby is usually called *balass*; if pale rose, *spinell*.

* *Cryst.* ii. 226. *Estner's Miner.*
† *Klaproth.*

The

(I) See *Kirwan's Mineralogy*, I.—*Klaproth in Beob. der Berlin*, VIII. 295. and *Beiträge*, I. 47.—*Mr Greville* and the *Count de Bournon* in the *Philosophical Transactions* 1798, p. 403. and in *Nicholson's Journal*, II. 540. and III. 5.—*Mr Hauy Jour. de Phys.* XXX. 193. and *Jour. de Min.* N° XXVIII. 262.

(K) See *Kirwan's Mineralogy*, I. 175, and *Schr.ber.* 15. *Stück*, p. 209.

(L) See *Kirwan's Min.* I. 253.—*Romé de Lisle*, II. 224.—*Klaproth Beob. der Berlin*, III. 336. and *Beiträge*, II. 1.—*Vauquelin Ann. de Chim.* XXVII. 3. and XXXI. 141.

(M) We shall afterwards distinguish this octohedron either by the epithet *regular* or *aluminiform*, because it is the well known form of crystals of alum.

Earths and Stones.

The ruby, according to the analysis of Vauquelin, is composed of

86.00 alumina,
8.50 magnesia,
5.25 chromic acid.

99.75 *

The ancients seem to have classed this stone among their hyacinths †.

* Ann de Chim. xxvi. 15
† Plin., l. 37. c. 9.

29

GENUS III. AIM.

SPECIES 1. Ceylanite.

G. III. AIM. Ceylanite.

The mineral denominated *ceylanite*, from the island of Ceylon, from which it was brought into Europe, had been observed by Romé de Lisle ‡; but was first described by La Metherie in the Journal de Physique for January 1793.

‡ Crystal. iii. 180 Note 21.

It is most commonly found in rounded masses; but sometimes also crystallized. The primitive form of its crystals is a regular octohedron: it commonly occurs under this form, but more commonly the edges of the octohedron are wanting, and small faces in their place ‡.

The fracture of the ceylanite is conchoidal *. Its internal lustre is glassy. Nearly opaque, except when in very thin pieces. Hardness 12. Sp. gr. from 3.7617 † to 3.793 ‡. Colour of the mass, black; of very thin pieces, deep green. Powder, greenish grey. According to the analysis of Descotils the ceylanite is composed of

68 alumina,
16 oxyd of iron,
12 magnesia,
2 silica.

98 §

‡ Hauy, Jour. de Min. No xxxviii. 161.
* Ibid. 263
† Hauy
‡ Descotils.
§ Ann. de Chim. xxiii. 113.

30

GENUS IV. S.

SPECIES 1. Quartz ||.

G. IV. S. Quartz.

This stone, which is very common in most mountainous countries, is sometimes crystallized, and sometimes amorphous. The primitive form of its crystals, according to Mr Hauy, is a rhomboidal parallelopiped; the angles of whole rhombs are 93° 22', and 86° 38'; so that it does not differ much from a cube *. The most common variety is a dodecahedron ‡, composed of two six-sided pyramids, applied base to base, whose sides are isosceles triangles, having the angle at the vertex 40°, and each of the angles at the base 70°; the inclination of a side of one pyramid to the contiguous side of the other pyramid is 104°. There is often a six-sided prism interposed between the two pyramids, the sides of which always correspond with those of the pyramids ||. For a description and figure of the other varieties of quartz crystals, and for a demonstration of the law which they have followed in crystallizing, we refer the reader to *Romé de Lisle* † and *Mr Hauy* ‡.

|| Kirwan's Min. i. 241.
* Jour de Min. No xxviii. 255.
‡ Fig. 6.
Fig. 7.
† Crystal. ii. 71.
‡ Mem. Par. 1786, p. 78 See also *Lametherie, Jour. de Phys.* xlii. 470.

The texture of quartz is more or less foliated. Fracture, conchoidal or splintery. Its lustre varies from 3 to 1, and its transparency from 4 to 1; and in some cases it is opaque. It causes a double refraction. Hardness, from 10 to 11. Sp. gr. from 2.64 to 2.67, and in one variety 2.691. Its colour is exceedingly various; a circumstance which has induced mineralogists to divide it into numerous varieties. Of these the following are the chief:

Simple Stones.

1. Pure colourless, perfectly transparent crystallized quartz, having much the appearance of artificial crystal; known by the name of *rock crystal*.

2. Quartz less transparent, and with a splintery fracture, has usually been distinguished by the name of *quartz*, and separated from rock crystal. As there is no occasion for this separation, we have, in imitation of Mr Hauy, chosen the word quartz for the *specific name*, comprehending under it all the varieties.

3. Blood red quartz; formerly called *crompostella hyacinth*, and by Hauy *quartz hematoide*. It owes its colour to oxyd of iron. The mineral known to mineralogists by the name of *sinople*, and considered by them as a variety of *jasper*, has been discovered by Dolomieu to be merely this variety of quartz in an amorphous state *.

4. Yellow quartz; called false topaz.

5. Rosy red quartz; called Bohemian ruby.

* Jour. de Min No xxviii. 255.

For a fuller enumeration of these varieties, we refer the reader to *Smeisser's Mineralogy* †, *Kirwan's Mineralogy* ‡, and Gmelin's edition of the *Systema Naturæ* of Linnæus §. This last writer, however, has arranged several minerals under quartz which do not belong to it.

† i. 89.
‡ i. 244.
§ iii. 194.

Pure quartz is composed entirely of silica; but some of the varieties of this species are contaminated with metallic oxyds, and with a small quantity of other earths.

SPECIES 2. Elastic Quartz (N).

31 Elastic quartz.

This singular stone is moderately elastic, and flexible in every direction. Texture, earthy. Lustre, 0 or 1. Hardness, 9. Brittle. Sp. gr. 2.624. Colour, greyish white. Phosphoresces when scraped with a knife in the dark. The specimen analysed by Mr Klaproth contained

96.5 silica,
2.5 alumina,
5 oxyd of iron,

99.5 †

† Beiträge, ii. 116.

SPECIES 3. Flint (O).

32 Flint.

Pyromachus—Pierre a fusil—Silex of Hauy.

This stone, which has become so necessary in modern war, is found in pieces of different sizes, and usually of a figure more or less globular, commonly among chalk, and often arranged in some kind of order. In Saxony it is said to have been found crystallized in hexahedrons, composed of two low three-sided pyramids applied base to base *.

* Gmelin's Systema Naturæ, iii. 183.

Its texture is compact. Its fracture, smooth conchoidal. Lustre, external 0, the stones being always covered by a white crust; internal 1, inclining to greasy. Transp. 2; when very thin, 3. Hardness, 10 or 11. Sp. gr. from 2.58 to 2.63. Colour varies from honey yellow to brownish black. Very brittle, and splits into splinters in every direction. Two pieces of flint rubbed smartly together phosphoresce, and emit a peculiar odour. When heated it decrepitates, and becomes white and opaque. When exposed long to the air

(N) *Kirwan's Min.* I. 316.—*Gerhard Mem. Berlin*, 1783. 107.—*Klaproth's Beitrage 2 Band.* 113. See also *Jour. de Phys.* XLI. 91.

(O) *Kirwan's Min.* I. 301.—*Dolomieu Jour de Min.* No XXXIII. 693. and *Salivet, ibid.* 713. These last gentlemen give the only accurate account of the method of making gun flints.

Earths and Stones.

air it often becomes covered with a white crust. A specimen of flint analysed by Klaproth contained

98.00 silica,
.50 lime,
.25 alumina,
0.25 oxyd of iron,
1.00 water.

100.00 †

† Beiträge, i. 46.

Another specimen analysed by Dolomieu was composed of 97 silica,
1 alumina and oxyd of iron,
2 water.

100 ‡

‡ Jour de Min No xxxiii 702.

The white crust with which flint is enveloped, consists of the same ingredients, and also a little carbonat of lime. Dolomieu discovered that water is essential to flint; for when it is separated by heat the stone loses its properties §.

§ Ibid.

The manufacture of gun flints is chiefly confined to two or three departments in France. The operation is exceedingly simple: a good workman will make a 1000 flints in a day. The whole art consists in striking the stone repeatedly with a kind of mallet, and bringing off at each stroke a splinter, sharp at one end and thicker at the other. These splinters are afterward shaped at pleasure, by laying the line at which it is wished they should break, upon a sharp iron instrument, and then giving it repeatedly small blows with a mallet. During the whole operation the workman holds the stone in his hand, or merely supports it on his knee ||.

|| Ibid.

33

SPECIES 4. Opal (P).

This stone is found in many parts of Europe. It is usually amorphous. Its fracture is conchoidal, commonly somewhat transparent. Hardness from 6 to 10. Sp. gr. from 1.7 to 2.66. The lowness of its specific gravity, in some cases, is to be ascribed to accidental cavities which the stone contains. These are sometimes filled with drops of water. Some specimens of opal have the property of emitting various coloured rays, with a particular effulgency, when placed between the eye and the light. The opals which possess this property, are distinguished by lapidaries by the epithet *oriental*; and often by mineralogists by the epithet *nobilis*. This property rendered the stone much esteemed by the ancients.

Variety 1. Opal edler—*Opalus nobilis*.

Lustre glassy, 3. Transp. 3 to 2. Hardness, 6 to 8. Colour, usually light bluish white, sometimes yellow or green. When heated it becomes opaque, and sometimes is decomposed by the action of the atmosphere. Hence it seems to follow, that water enters essentially into its composition. A specimen of this variety, analysed by Klaproth, contained

90 silica,
10 water.

100 ¶.

Variety 2. Semi-opal.

Fracture, imperfectly conchoidal. Lustre, glassy 2. Transp. 2 to 3. Hardness, 7 to 9. Its colours are very various, greys, yellows, reds, browns, greens of different kinds.

Simple Stones.

Specimens of this variety sometimes occur with rifts: these readily imbibe water, and therefore adhere to the tongue. These specimens sometimes become transparent when soaked in water, by imbibing that fluid. They are then called *hydrophanes*.

Variety 3. Cat's eye *.

* Kir. Min. Klaproth, Beiträge, i. 90.

This variety comes from Ceylon, and is seldom seen by European mineralogists till it has been polished by the lapidary. Mr Klaproth has described a specimen which he received in its natural state from Mr Greville of London. Its figure was nearly square, with sharp edges, a rough surface, and a good deal of brilliancy.

Its texture is imperfectly foliated. Lustre greasy, 2. Transp. 3 to 2. Hardness 10. Sp. gr. 2.56 to 2.66. Colour, grey; with a tinge of green, yellow or white; or brown, with a tinge of yellow or red. In certain positions it reflects a splendid white, as does the eye of a cat; hence the name of this stone.

Two specimens, analysed by Klaproth, the first from Ceylon, the other from Malabar, were composed of

95.00	94.50	silica,
1.75	2.00	alumina,
1.50	1.50	lime,
0.25	0.25	oxyd of iron.
98.5 *	98.25 †.	

* Beiträge, i. 94
† Ibid p. 96.

SPECIES 5. Pitchstone §.
Menelites.

34 Pitchstone.
§ Kir. Min. i. 92.—Dolomieu, Mem. Par. 1787, p. 80.

This stone, which occurs in different parts of Germany, France, and other countries, has obtained its name from some resemblance which it has been supposed to have to pitch. It is most usually in amorphous pieces of different sizes; and it has been found also crystallized in six-sided prisms, terminated by three-sided pyramids.

Its texture is conchoidal and uneven, and sometimes approaches the splintery. Lustre greasy, from 3 to 1. Transp. 2 to 1, sometimes 0. Hardness 8 to 10. Exceedingly brittle; it yields even to the nail of the finger. Sp. gr. 2.049 to 2.39. Its colours are numerous, greyish black, bluish grey, green, red, yellow of different shades. Sometimes several of these colours appear together in the same stone. A specimen of pitchstone from Mesnil-montant near Paris *, analysed by Mr Klaproth, contained

* See Jour. Phys. xxxi. 219.

85.5 silica,
11.0 air and water,
1.0 alumina,
.5 iron,
.5 lime and magnesia.

98.5 †

† Beiträg ii 169.

SPECIES 6. Chrysoprasium (Q).

35 Chrysoprasium.

This mineral, which is found in different parts of Germany, particularly near Kosemütz in Silesia, is always amorphous. Its fracture is either even or inclining to the splintery. Scarcely any lustre. Transp. 2 to 3. Hardness 10 to 12. Sp. gr. 2.479. Colour, green. In a heat of 130° Wedgewood it whitens and becomes opaque.

A

(P) *Kirwan's Min.* I. 289.—*Hauy, Jour. d'Hist. Nat.* II. 9. *Delius. Nouv. Jour. de Phys.* I. 45.
(Q) *Kirwan's Min.* I.—*Lehmann. Mem. Berlin.* 1755. *p.* 202.—*Klaproth Beitrage*, II. 127.

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A specimen of this stone, analysed by Mr Klaproth, contained

96.16 silica,
1.00 oxyd of nickel,
0.83 lime,
0.08 alumina,
0.08 oxyd of iron.

98.15 ‡

‡ Schrift. ... 16 G. V. 1. AS. Topaz.

GENUS V. 1. AS.

SPECIES 1. Topaz (R).

Occidental ruby, topaz, and sapphyr.

The name *topaz* has been restricted by Mr Hauy to the stones called by mineralogists occidental ruby, topaz, and sapphyr; which, agreeing in their crystallization and most of their properties, were arranged under one species by Mr Romé de Lisle. The word *topaz*, derived from an island in the Red Sea (S), where the ancients used to find topazes, was applied by them to a mineral very different from ours. One variety of our topaz they denominated *chrysolite*.

The topaz is found in Saxony, Bohemia, Siberia, and Brazil, mixed with other minerals in granite rocks.

It is commonly crystallized. The primitive form of its crystals is a prism whose sides are rectangles, and bases rhombs, having their greatest angles 124° 22', and the integral molecule has the same form*; and the height of the prism is to a side of the rhomboidal bases as 3 to 2 †. The different varieties of topaz crystals hitherto observed, amount to 6. Five of these are eight-sided prisms, terminated by four-sided pyramids, or wedge shaped summits, or by irregular figures of 7, 13, or 15 sides‖; the last variety is a twelve sided prism, terminated by six-sided pyramids wanting the apex. For an accurate description and figure of these varieties we refer the reader to Mr Hauy ‡.

* Hauy, Jour. de Min. N° xxviii, 2..
† Fig. 8.
‖ Fig. 9.
‡ Jour. de Min. ibid.

The texture of the topaz is foliated. Its lustre is from 2 to 4. Transp. from 2 to 4. It causes a double refraction. Hardness 12 to 14. Sp. gr. from 3.5311 to 3.564. The Siberian and Brazil topazes, when heated, become positively electrified on one side, and negatively on the other §. It is infusible by the blowpipe. The yellow topaz of Brazil becomes red when exposed to a strong heat in a crucible; that of Saxony becomes white by the same process. This shews us, that the colouring matter of these two stones is different.

§ Hauy, ib.

The colour of the topaz is various, which has induced mineralogists to divide it into the following varieties:

1. Red topaz, of a red colour inclining to yellow; called *Brazilian* or *occidental ruby*.

2. Yellow topaz, of a golden yellow colour, and sometimes also nearly white; called *occidental* or *Brazil topaz*. The powder of this and the following variety causes syrup of violets to assume a green colour ‖.

3. *Saxon topaz*. It is of a pale wine yellow colour, and sometimes greyish white.

‖ Vauquelin, Jour. de Min N° xxix. 105.

4. *Aigue marine*. It is of a bluish or pale green colour.

Simple Stones.

5. *Occidental sapphyr*. It is of a blue colour; and sometimes white.

A specimen of white Saxon topaz, analysed by Vauquelin, contained

68 alumina,
31 silica.

99 ¶

¶ Jour. de Min N° xxiv. 3.

SPECIES 2. Sommite.

37 Sommite.

This stone was called sommite by La Metherie, from the moutain Somma, where it was first found. It is usually mixed with volcanic productions. It crystallizes in six-sided prisms, sometimes terminated by pyramids. Colour white. Somewhat transparent. Sp. gr. 3.2741. Infusible by the blow-pipe. According to the analysis of Vauquelin, it is composed of

49 alumina,
46 silica,
2 lime,
1 oxyd of iron.

98 *

* Ibid. N° xxvii. 279.

SPECIES 3. Shorlite †.

38 Shorlite.

This stone, which received its name from Mr Klaproth, is generally found, in irregular oblong masses or columns, inserted in granite. Its texture is foliated. Fracture uneven. Lustre 2. Transparency 2 to 1. Hardness 9 to 10. Sp. gr. 3.53. Colour greenish white, or sulphur yellow. Not altered by heat. According to the analysis of Klaproth, it is composed of

† Kirwan's Min. i. 286.

50 alumina,
50 silica.

100

GENUS V. 2. SA.

39 G. V. 2. SA. Rubellite.

SPECIES 4. Rubellite (T).

Red shorl of Siberia.

This stone is found in Siberia mixed with white quartz. It is crystallized in small needles, which are grouped together and traverse the quartz in various directions. Texture fibrous. Fracture even, inclining to the conchoidal. Transparency 2; at the edges 3. Hardness 10. Brittle. Sp. gr. 3.1. Colour crimson, blood or peach red. By exposure to a red heat it becomes snow white; but loses none of its weight. It tinges soda blue, but does not melt with it.

According to the analysis of Mr Bindheim, it is composed of

57 silica,
35 alumina,
5 oxyds of iron and manganese.

97

SPECIES 5. Hornslate (U).

40 Hornslate.

Shistose-porphyry.

This stone, which occurs in mountains, is generally amorphous; but sometimes also in columns. Structure

(R) Kirwan's Min. I. 254.—Pott. Mem. Berlin, 1747, p. 46.—Margraf, ibid. 1776, p. 73. and 160.—Henkel. Act. Acad. Nat. Cur. IV. 316.

(S) It got its name from τοπαζειν, to seek, because the island was often surrounded with fog, and therefore difficult to find. See Plinii lib. 37. c. 8.

(T) Kirwan's Min I. 288. Bindheim Crell's Annals, 1792 p. 320.

(U) Kirwan's Min. I. 307.—Wiegleb. Crell's Annals, 1787. 1 Band. 302.—See also Reuss. Samml. Natur. Hyst. Aufsäze, p 207.

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ture slaty. Texture foliated. Fracture uneven and splintery; sometimes approaching the conchoidal. Lustre 0. Transparency 1 or 0. Hardness about 10. Sp. gr. from 2.512 to 2.7. Colour different shades of *grey*, from *ash* to *bluish* or *olive green*. Melts at 140 Wedgewood into an enamel. A specimen, analysed by Wedgewood, contained

73.0	silica,
23.9	alumina,
3.5	iron.
100.4	

41 Hornstone.

SPECIES 6. Hornstone (x).

Petrosilex—Chert.

This stone, which makes a part of many mountains, is usually amorphous; but, as Mr Kirwan informs us, it has been found crystallized by Mr Beyer on Schneeberg. Its crystals are six sided prisms, sometimes terminated by pyramids; hexahedrons, consisting of two three-sided pyramids applied base to base; and cubes, or six-sided plates *. Its texture is foliated. Fracture splintery, and sometimes conchoidal. Lustre 0. Transparency 1 to 2. The crystals are sometimes opaque. Hardness 7 to 9. Sp. gr. 2.532 to 2.653. Colour usually dark blue: but hornstone occurs also of the following colours; grey, red, blue, green, and brown of different shades †.

According to Kirwan, it is composed of

72	silica,
22	alumina,
6	carbonat of lime.
100 ‡	

* Kirwan, i. 303.

† Schmeisser's Min. i. 103.

‡ Ibid. p. 105.

42 Chalcedony.

SPECIES 7. Chalcedony.

This stone is found abundantly in many countries, particularly in Iceland and the Faro islands. It is most commonly amorphous, stalactitical, or in rounded masses; but it occurs also crystallized in six-sided prisms, terminated by pyramids, or more commonly in four or six sided pyramids, whose sides are convex. Surface rough. Fracture more or less conchoidal. Lustre 1. Somewhat transparent. Hardness 10 to 11. Sp. gr. 2.56 to 2.665. Not brittle.

According to Bergman, the chalcedony of Faroe is composed of

84	silica,
16	alumina, mixed with iron.
100	

Variety 1. Common chalcedony.

Fracture even, inclining to conchoidal. Transparency 2 to 3; sometimes 1. Its colours are various; it is most commonly greyish, with a tint of yellow, green, blue, or pearl; often also white, green, red, yellow, brown, black, or dotted with red. When striped white and black, or brown, alternately, it is called *onyx*; when striped white and grey, it is called *chalcedonix*. Black or brown chalcedony, when held between the eye and a strong light, appears dark red.

Variety 2. Cornelian.

Fracture conchoidal. Transparency 3 to 1; often cloudy. Its colours are various shades of red, brown, and yellow. Several colours often appear in the same mass. To this variety belong many of the stones known by the name of *Scotch pebbles*.

Simple Stones.

SPECIES 8. Jasper (y).

This stone is an ingredient in the composition of many mountains. It occurs usually in large amorphous masses, and sometimes also crystallized in six sided irregular prisms. Its fracture is conchoidal. Lustre from 2 to 0. Either opaque, or its transparency is 1. Hardness 9 to 10. Sp. gr. from 2.5 to 2.82. Its colours are various. When heated, it does not decripitate. It seems to be composed of silica and alumina, and often also contains iron. 43 Jasper.

Variety 1. Common jasper.

Sp. gr. from 2.58 to 2.7. Its colours are, different shades of white, yellow, red, brown, and green; often variegated, spotted, or veined, with several colours.

Variety 2. Egyptian pebble.

This variety is found chiefly in Egypt. It usually has a spheroidal or flat rounded figure, and is enveloped in a coarse rough crust It is opaque. Hardness 1[illegible]. Sp. gr. 2.564. It is chiefly distinguished by the variety of colours, which always exist in the same specimen, either in concentric stripes or layers, or in dots or dentritical figures These colours are, different browns and yellows, milk white, and isabella green; black also has been observed in dots.

Variety 3. Striped jasper.

This variety is also distinguished by concentric stripes or layers of different colours: these colours are, yellow, brownish red, and green. It is distinguished from the last variety by its occurring in large amorphous masses, and by its fracture, which is nearly even.

SPECIES 9. Tripoli. 44 Tripoli.

This mineral is found sometimes in an earthy form, but more generally indurated. Its texture is earthy. Its fracture often somewhat conchoidal. Lustre 0. Generally opaque. Hardness 4 to 7 Sp gr. 2.080 to 2.529. Absorbs water. Feel, harsh dry. Hardly adheres to the tongue. Takes no polish from the nail. Does not stain the fingers Colour generally pale yellowish grey, also different kinds of yellow, brown, and white.

It contains, according to Haasse, 90 parts of silica, 7 alumina, and 3 of iron. A mineral belonging to this species was analysed by Klaproth, and found to contain

66.5	silica,
7.0	alumina,
2.5	oxyd of iron,
1.5	magnesia,
1.25	lime,
19.	air and water.
97.75	

GENUS VI. I. ASI.

SPECIES 1. Micarell *. 45 VI. r. ASI. Micarell.

This name has been given by Mr Kirwan to a stone which former mineralogists considered as a variety of * Kirw. mica. It is found in granite. Its texture is foliated, [illegible] and

(x) *Kirwan's Min.* I. 303.—*Baumer Jour. de Phys.* II. 154. and *Monnet, ibid.* 331.—*Wiegleb. Crell's Annals*, 1788, *p.* 45 and 135.

(y) *Kirw. Min.* I. 309.—*Borral Hist. Natur. de Corse.*—*Henkel Act. Acad. Nat. Curios.* V. 339.

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and it may be split into thin plates. Lustre metallic, 3. Opaque. Hardness 6. Sp gr. 2.980. Colour brownish black. At 153° Wedgewood, it melts into a black compact glass, the surface of which is reddish †.

† Kirw. i. 3??

A specimen analysed by Klaproth contained

63.00 alumina,
29.50 silica,
6.75 iron.

—————

99.25

46 Shorl. Kirw. i. 265.

SPECIES 2. Shorl ‡.

No word has been used by mineralogists with less limitation than *shorl*. It was first introduced into mineralogy by Cronstedt, to denote any stone of a columnar form, considerable hardness, and a specific gravity from 3 to 3.4. This description applied to a very great number of stones. And succeeding mineralogists, though they made the word more definite in its signification, left it still so general, that under the designation of *shorl* almost 20 distinct species of minerals were included.

Mr Werner first defined the word *shorl* precisely, and restricted it to one species of stones. We use the word in the sense assigned by him.

Shorl is found abundantly in mountains, either massive or crystallized, in three or nine sided prisms, often terminated by three sided summits. The sides of the crystals are longitudinally streaked. Its texture is foliated. Its fracture conchoidal. Lustre 2. Opaque. Hardness 10. Sp. gr. 2.92 to 3.212. Colour black. Streak grey. It does not become electric by heat. When heated to redness, its colour becomes brownish red; and at 127° Wedgewood, it is converted into a brownish compact enamel *. According to Wiegleb, it is composed of

* Ibid. i. 166.

41.25 alumina,
34.16 silica,
20.00 iron,
5.41 manganese.

—————

100.82 †

† Crell's ... i.

SPECIES 5. Granatite.

Staurolide of Hauy—*Pierre de Croix* of De Lisle—*Staurolithe* of Lametherie.

47 Granatite.

We have adopted from Mr Vauquelin the term *granatite* to denote this stone, because all the other names are ambiguous, having been applied to another mineral possessed of very different properties.

Granatite is found in Galicia in Spain, and Britanny in France. It is always crystallized in a very peculiar form; two six sided prisms intersect each other, either at right angles or obliquely ‡. Hence the name *croisette*, by which it was known in France and Spain *. Mr Hauy has proved, in a very ingenious manner, that the primitive form of the granatite is a rectangular prism, whose bases are rhombs, with angles of 129½° and 50½°; and that the height of the prism is to the greater diagonal of a rhomb as 1 to 6; and that its integrant molecules are triangular prisms, similar to what would be obtained by cutting the primitive crystal in two, by a plane passing vertically through the shorter diagonal of the rhomboidal base. From this structure he has demonstrated the law of the formation of the cruciform varieties *. The colour of granatite is greyish or reddish brown.

‡ Fig. 10.
* Romé de Lisle, ii. 435.

Simple Stones.

* Ann. de Chim. vi. 142.

According to the analysis of Vauquelin, it is composed of

47.06 alumina,
30.59 silica,
15.30 oxyd of iron,
3.00 lime.

—————

95.95 †

† Ibid xxx. 100.

GENUS VI. 2. SAL.

SPECIES 4. Tourmaline (z).

48 G. VI. 2. Sal. Tourmaline.

This stone was first made known in Europe by specimens brought from Ceylon; but it is now found frequently forming a part of the composition of mountains. It is either in amorphous pieces, or crystallized in three or nine sided prisms, with four sided summits.

Its texture is foliated: Its fracture conchoidal. Internal lustre 2 to 3. Transparency 3 to 4; sometimes only 2 (A). Causes only single refraction *. Hardness 9 to 11. Sp. gr. 3.05 to 3.155. Colour brown, often so dark that the stone appears black; the brown has also sometimes a tint of green, blue, red, or yellow.

* Hauy, Jour. de Min. No xxviii. 265.

When heated to 200° Fahrenheit, it becomes electric; one of the summits of the crystal negatively, the other positively †. It reddens when heated; and is fusible *per se* with intumescence into a white or grey enamel.

† Æpinus.

A specimen of the tourmaline of Ceylon, analysed by Vauquelin, was composed of

40 silica,
39 alumina,
12 oxyd of iron,
4 lime,
2.5 oxyd of manganese,

—————

97.5 ‡.

‡ Ann. de Chim. xxx. 105.

SPECIES 5. Argentine felspar §.

49 Argentine felspar.

§ Kirwan, i. 327.

This stone was discovered by Mr Dodun in the black mountains of Languedoc. It is either amorphous, or crystallized in rhomboidal tables, or six or eight sided prisms. Its texture is foliated. Fragments rectangular. Laminæ inflexible. Internal lustre 4. Transparency 2. Colour white; two opposite faces of the crystals are silver white, two others dead white. Hardness of the silvery laminæ 6, of the rest 9. Brittle. Sp. gr. 2.5. When the flame of the blow-pipe is directed against the edges of the crystal (stuck upon glass), it easily melts into a clear compact glass; but when the flame is directed against the faces, they preserve their lustre, and the edges alone slowly melt.

According to the analysis of Dodun, it is composed of

46 silica,
36 alumina,
16 oxyd of iron,

—

98

When this stone is exposed to the atmosphere, it is apt

(z) *Kirw.* I. 271.—*Berg.* II. 118. and V 402.—*Gerhard. Mem. Berlin*, 1777, p. 14.—*Hauy Mem: Par.* 1784, 270.—*Wilson Phil. Transf.* XLI. 308.—*Æpinus. Recueil sur la Tourmaline.* See also *La Porterie. Le Sapphir, l'Oeil de Chat, et la Tourmaline de Ceylon démasqués.*

(A) And when black only 1.

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apt to decay: Its ſurface becomes irideſcent, and at laſt changes to ochre yellow: Its ſpecific gravity is 2.3 or 2.212; and when breathed upon, it gives out an earthy ſmell.

50 Mica.

SPECIES 6. Mica ||.

|| Kirw. i. 2.0—Gmelin, Nov. Com. Petropol. xii. 549.

This ſtone forms an eſſential part of many mountains, and has been long known under the names of *glacies mariæ* and *Muſcovy glaſs*. It conſiſts of a great number of thin laminæ adhering to each other, ſometimes of a very large ſize. Specimens have been found in Siberia nearly 2½ yards ſquare (B).

It is ſometimes cryſtallized: Its primitive form is a rectangular priſm, whoſe baſes are rhombs, with angles of 120° and 60° †: Its integrant molecule has the ſame form. Sometimes it occurs in rectangular priſms, whoſe baſes alſo are rectangles, and ſometimes alſo in ſhort fixſided priſms †; but it is much more frequently in plates or ſcales of no determinate figure or ſize *.

† Fig. 11.

† Fig. 12.

* Hauy, Jour. de Min. N° xxviii. 296.

Its texture is foliated. Its fragments flat. The lamellæ flexible, and ſomewhat elaſtic. Luſtre metallic, from 3 to 4. Tranſparency of the laminæ 3 or 4, ſometimes only 2 (C). Hardneſs 6. Very tough. Often abſorbs water. Sp. gr. from 2.6546 to 2.9342. Feels ſmooth, but not greaſy. Powder feels greaſy. Colour, when pureſt, ſilver white or grey; but it occurs alſo yellow, greeniſh, reddiſh, brown, and black. Mica is fuſible by the blow-pipe into a white, grey, green, or black, enamel; and this laſt is attracted by the magnet (D). Spaniſh wax rubbed by it becomes negatively electric *.

* Ibid.

A ſpecimen of mica, analyſed by Vauquelin, contained

50.00 ſilica,
35.00 alumina,
7.00 oxyd of iron,
1.35 magneſia,
1.33 lime,

94.68 †.

† Ibid. 302.

Mica has long been employed as a ſubſtitute for glaſs. A great quantity of it is ſaid to be uſed in the Ruſſian marine for panes to the cabin windows of ſhips; it is preferred, becauſe it is not ſo liable as glaſs to be broken by the agitation of the ſhip.

51 Talc.

SPECIES 7. Talc ‡.

‡ Kirw. i. 150.—Pott. Mem. Berl. 1746, p. 65.

This ſtone has a very ſtrong reſemblance to mica, and was long conſidered as a mere variety of that mineral. It occurs ſometimes in ſmall looſe ſcales, and ſometimes in an indurated form; but it has not hitherto been found cryſtallized.

Its texture is foliated. The lamellæ are flexible, but not elaſtic. Its luſtre is from 2 to 4. Tranſparency from 2 to 4. Hardneſs 4 to 6. Sp. gr. when indurated, from 2.7 to 2.8. Feels greaſy. Colour moſt commonly whitiſh or greeniſh. Spaniſh wax rubbed with it becomes *poſitively* electric §.

§ Hauy, Jour. de Min. N° xxviii. 291.

Variety 1. Scaly talc.
Talcite of Kirwan.

This variety occurs under the form of ſmall ſcales, ſcarcely cohering. Luſtre 3 to 4. Very light. Adheres to the fingers. When rubbed upon the ſkin, it gives it a gloſs. Colour white, with a ſhade of red or green; ſometimes leek green.

Simple Stones.

Variety 2. Common talc.
Venetian talc.

This variety often occurs in oblong nodules. Luſtre, nearly metallic, 4. Tranſparency 2 to 3; when very thin 4. Hardneſs 4 to 5. Colour white, with a ſhade of green or red; or apple green, verging towards ſilver white. By tranſmitted light green.

Variety 3. Shiſtoſe talc.

Its ſtructure is ſlaty. Fracture hackly and long ſplintery. Eaſily crumbles when rubbed in the fracture. External luſtre 2 to 3; internal, 1; but ſometimes, in certain poſitions, 3. Colour grey, with a ſhade of white, green or blue. Becomes white and ſcaly when expoſed to the air.

A ſpecimen of *common talc*, analyſed by Mr Chenevix, contained

48.0 ſilica,
37.0 alumina,
6.0 oxyd of iron,
1.5 magneſia,
1.5 lime,
5.0 water,

99.0 *.

* Ann. de Chim. xxviii. 200.

SPECIES 8. Baſaltine †.

52 Baſaltine.

† Kirw. 219.

Baſaltic hornblende of Werner—*Actinote* of Hauy—*Zillertite* of Lametherie—*Shorl priſmatique hexagone* of Sauſſure.

This ſtone is found commonly in baſaltic rocks; hence its name, which we have borrowed from Mr Kirwan. It is cryſtallized, either in rhomboidal priſms, or ſix or eight ſided priſms, terminated by three-ſided pyramids. Its texture is foliated. Its fracture uneven. Luſtre 3. Tranſparency, when in very thin plates, 1. Hardneſs from 9 to 10. Sp. gr. 3.333. Colour black, dark green, or yellowiſh green. Streak white. Tranſmits a reddiſh yellow light. Before the blow-pipe, it melts into a greyiſh coloured enamel, with a tint of yellow †. A ſpecimen, ſeemingly of this ſtone, analyſed by Bergman, contained

† Le Lièvre, Jour. de Min. N° xxviii. 209.

58 ſilica,
27 alumina,
9 iron,
4 lime,
1 magneſia,

99 ‡.

‡ Bergm. 207.

SPECIES 9. Hornblende ¶.
Amphibole of Hauy (E).

53 Hornblende.

¶ Kirw. i. 213.

This ſtone enters into the compoſition of various mountains. Its texture is very conſpicuouſly foliated. Fracture conchoidal. Fragments often rhomboidal. Luſtre 2. Opaque. Hardneſs 5 to 9. Tough. Sp. gr. 2.922 to 3.41. Colour black, blackiſh green, olive green

(B) *Hiſt. General de Voyages*, T. XVIII. 272, quoted by Hauy *Jour. de Min.* N° XXVIII. 299.

(C) Black mica is often nearly opaque.

(D) *Hauy*, *ibid.* p. 295. Bergman, however, found pure mica infuſible *per ſe*; and this has been the caſe with all the ſpecimens of Muſcovy glaſs which we have tried.

(E) We ſuſpect, that under this name Mr Hauy comprehends *ſhorl* alſo.

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green, or leek green. Streak greenifh. It neither becomes electric by friction nor heat *. Before the blow-pipe it melts into a black glafs. A fpecimen of black hornblende, analyfed by Mr Hermann, was compofed of

37 filica,
27 alumina,
25 iron,
5 lime.
3 magnefia,

97 †

* Hauy, Jour. de Min. N° xxviii. 267.

† Ibid. Berlin, 5 ...

SPECIES 10. Refplendent Hornblende.

54 Refplendent hornblende.

There are two minerals which Werner confiders as varieties of hornblende, and Mr Kirwan as conftituting a diftinct fpecies. Thefe, till future analyfes decide the point, we fhall place here under the name of refplendent hornblende, the name given them by Mr Kirwan; and we fhall defcribe them feparately.

Variety 1. Labradore hornblende.

Texture, curved foliated. Luftre, in fome pofitions, 2; in others metallic, and from 3 to 4. Opaque. Hardnefs 8 to 9. Sp. gr. from 3.35 to 3.434. Colour, in moft pofitions, greyifh black; in others, it reflects a ftrong iron grey, fometimes mixed with copper red.

Variety 2. Shiller fpar *.

Texture foliated. Luftre metallic, 4. Tranfparency, in thin pieces, 1. Hardnefs 8 to 9. Sp. gr. 2.882. Colour, green, often with a fhade of yellow: alfo golden yellow. In fome pofitions it reflects white, grey, or yellow. At 141 Wedgewood, hardened into a porcelain mafs. A fpecimen, analyzed by Gmelin, was compofed of

43.7 filica,
17.9 alumina,
13.7 iron,
21.2 magnefia.

96.5 †

* Kirwan, i. 211

† Per Schr. Berl. 9 Band. p. 92.

It has been found in the Hartz, ftuck in a ferpentine rock.

SPECIES 11. Obfidian ‖.

Iceland agate.

55 Obfidian.

‖ Kirwan i. 264

This ftone is found either in detached maffes, or forming a part of the rocks which compofe many mountains. It is ufually invefted with a grey or opaque cruft. Its fracture is conchoidal. Its internal luftre 3. Tranfparency 1. Hardnefs 10. Sp. gr. 2.348. Colour black or greyifh black; when in very thin pieces, green. It melts into an opaque grey mafs. According to Bergman, it is compofed of

69 filica,
22 alumina,
9 iron.

100 §.

§ Bergm. iii. 204

SPECIES 12. Petrilite *.

Cubic felfpar.

56 Petrilite.

* Kirw. i. 325.

This ftone is found in the mafs of mountains. It is amorphous. Texture foliated. Fracture fplintery. Fragments cubic, or inclining to that form; their faces unpolifhed. Luftre 2. Tranfparency partly 2, partly 1. Hardnefs 9. Sp. gr. 3.081. Colour reddifh brown. Does not melt at 160 Wedgewood.

SPECIES 13. Felfite †.

Compact felfpar.

57 Felfite.

This ftone alfo forms a part of many mountains, and is amorphous. Texture fomewhat foliated. Fracture uneven, approaching to the fplintery. Luftre 1. Tranfparency fcarce 1. Hardnefs 9. Colour azure blue, and fometimes brown and green. Streak white. Before the blow-pipe, whitens and becomes rifty; but is infufible *per fe*.

Simple

GENUS VII. SAP.

58 G. VII. SAP. Felfpar.

SPECIES 1. Felfpar ‡.

‡ Kirw. i. 316. and Jour. de Phyf. paffim.

This ftone forms the principal part of many of the higheft mountains. It is commonly cryftallized. Its primitive form, according to De Lifle, is a rectangular prifm, whofe bafes are rhombs, with angles of 65° and 115° †. Sometimes the edges of the prifm are wanting, and faces in their place; and fometimes this is the cafe alfo with the acute angles of the rhomb. For a defcription and figure of thefe, and other varieties, we refer the reader to *Rome de Lifle* *, *Mr Hauy* †, and *Mr Pini* ‡.

† Fig. 13. and 14.

* Cryftall. ii. 461.

† Mem. Par. 1784, p. 273.

‡ Sur de Nouvelle Cryftallifation, &c. 8.

Its texture is foliated. Its crofs fracture uneven. Fragments rhomboidal, and commonly fmooth and polifhed on four fides. Luftre of the polifhed faces often 3. Tranfparency from 3 to 1. Hardnefs 9 to 10. Sp. gr. from 2.437 to 2.7. Gives a peculiar odour when rubbed. It is made electric with great difficulty by friction. Fufible *per fe* into a more or lefs tranfparent glafs. When cryftallized, it decrepitates before the blow-pipe.

Variety 1. Pure Felfpar.

Moon ftone—Adularia.

This is the pureft felfpar hitherto found. It occurs in Ceylon and Switzerland; and was firft mentioned by Mr Sage. Luftre nearly 3. Tranfparency 2 to 3. Hardnefs 10. Sp. gr. 2.559. Colour white; fometimes with a fhade of yellow, green, or red. Its furface is fometimes iridefcent.

Variety 2. Common Felfpar.

Luftre of the crofs fracture 0; of the fracture, in the direction of the laminæ, from 3 to 1. Tranfparency 2 to 1. Colour moft commonly flefh red; but often bluifh grey, yellowifh white, milk white, brownifh yellow; and fometimes blue, olive green, and even black.

Variety 3. Labradore felfpar.

This variety was difcovered on the coaft of Labradore by Mr Wolfe; and fince that time it has been found in Europe. Luftre 2 to 3. Tranfparency from 1 to 3. Sp. gr. from 2.67 to 2.6925. Colour grey. In certain pofitions, fpots of it reflect a blue, purple, red, or green colour.

Variety 4. Continuous felfpar.

This variety moft probably belongs to a different fpecies; but as it has not hitherto been analyfed, we did not think ourfelves at liberty to alter its place.

It is found in large maffes. Texture earthy. Fracture uneven, fometimes fplintery. Luftre 0. Tranfparency 1. Hardnefs 10. Sp. gr. 2.609. Colour reddifh grey, reddifh yellow, flefh red.

A fpecimen of green felfpar from Siberia, analyfed by Vauquelin, contained

62.83 filica,
17.02 alumina,
16.00 potafs,
3.00 lime,
1.00 oxyd of iron.

99.85 ‖

‖ Ann. de Chim. xxx

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SPECIES 2. Lepidolite (F).

Lilalite.

59 Lepidolite.

This stone appears to have been first observed by the Abbé Poda, and to have been first described by De Born §. Hitherto it has only been found in Moravia in Germany, and Sudermania in Sweden *. There it is mixed with granite in large amorphous masses. It is composed of thin plates, easily separated, and not unlike those of mica †. Lustre, pearly 3. Transparency between 1 and 2. Hardness 4 to 5. Not easily pulverised ‡. Sp. gr. from 2.816 ‖ to 2.8549 ¶. Colour of the mass, violet blue; of the thin plates, silvery white. Powder white, with a tint of red §. Before the blowpipe, it froths, and melts easily into a white semitransparent enamel, full of bubbles. Dissolves in borax with effervescence, and communicates no colour to it *. Effervesces slightly with soda, and melts into a mass spotted with red. With microcosmic salt, it gives a pearl coloured globule †.

This stone was first called lilalite from its colour, that of the *lily*. Klaproth, who discovered its component parts, gave it the name of *lepidolite* (G).

It is composed of

53 silica,
20 alumina,
18 potash,
5 fluat of lime,
3 oxyd of manganese,
1 oxyd of iron.

100 ‡

§ *Crell's Annals*, 1791, ii. 196.
* *Beyer*, *Ann. de Chim.* xxix. 158.
† *Le Lievre*, *Jour. de Min.* No li. 219.
‡ *Ibid.*
‖ *Klaproth.*
¶ *Hauy.*
§ *Le Lievre*, *Jour de Min.* No li. 219.
* *Ibid.*
† *Klaproth*, *Ann de Chim.* xxii. 87.
‡ *Vauquelin*, *Ann. de Chim.* xxx. 105.

SPECIES 3. Leucite ‖.

Vesuvian of Kirwan—*White garnet* of Vesuvius.

60 Leucite.

This stone is usually found in volcanic productions, and is very abundant in the neighbourhood of Vesuvius. It is always crystallized. The primitive form of its crystals is either a cube or a rhomboidal dodecahedron, and its integrant molecules are tetrahedrons; but the varieties hitherto observed are all polyhedrons: The most common has a spheroidal figure, and is bounded by 24 equal and similar trapeziods †; sometimes the faces are 12, 18, 36, 54, and triangular, pentagonal, &c. For a description and figure of several of these, we refer the reader to Mr Hauy ‖. The crystals vary from the size of a pin head to that of an inch.

The texture of the leucite is foliated. Its fracture somewhat conchoidal. Lustre 3; when in a state of decomposition 0. Transparency 3 to 2; when decomposing 0. Hardness 8 to 10; when decomposing 5 to 6. Sp. gr. 2.4648. Colour white, or greyish white (H). Its powder causes syrup of violets to assume a green colour *.

It is composed, as Klaproth has shewn, of

54 silica,
23 alumina,
22 potash.

99 (I)

‖ *Kirw.* i. 285.
† Fig. 15.
‖ *Jour de Min.* No xxvii. 185.
* *Vauquelin*, *Jour. de Min.* No xxxix. 165.

It was by analysing this stone that Klaproth discovered the presence of potash in the mineral kingdom; which is not the least important of the numerous discoveries of that accurate and illustrious chemist.

Simple Stones.

Leucite is found sometimes in rocks which have never been exposed to volcanic fire; and Mr Dolomieu has rendered it probable, from the situations in which it is found, that the leucite of volcanoes has not been formed by volcanic fire, but that it existed previously in the rocks upon which the volcanoes have acted, and that it was thrown out unaltered in fragments of these rocks §.

§ *Jour de Min.* No xxxix. 177.

GENUS VIII. SAG.

SPECIES 1. Emerald (K).

61 Gen. VIII sag. Emerald.

This stone has hitherto been only found crystallized. The primitive form of its crystals is a regular six-sided prism; and the form of its integrant molecules is a triangular prism, whose sides are squares, and bases equilateral triangles *. The most common variety of its crystals is the regular six-sided prism, sometimes with the edges of the prism, or of the bases, or the solid angles, or both wanting ‡, and small faces in their place †. The sides of the prism are generally channelled.

Its texture is foliated. Its fracture conchoidal. Lustre usually from 3 to 4. Transparency from 2 to 4. Causes a double refraction. Hardness 12. Sp. gr. 2.65 to 2.775. Colour green. Becomes electric by friction, but not by heat. Its powder does not phosphoresce when thrown on a hot iron †. At 150° Wedgewood it melts into an opaque coloured mass. According to Dolomieu, it is fusible *per se* by the blow-pipe ‡.

This mineral was formerly subdivided into two distinct species, the *emerald*, and *beryl* or *aqua marina*. Hauy demonstrated, that the emerald and beryl corresponded exactly in their structure and properties, and Vauquelin found that they were composed of the same ingredients, henceforth, therefore, they must be considered as varieties of the same species.

The variety formerly called *emerald* varies in colour from the pale to the perfect green. When heated to 120° Wedgewood, it becomes *blue*, but recovers its colour when cold. A specimen, analysed by Vauquelin, was composed of

64.60 silica,
14.00 alumina,
13.00 glucina,
3.50 oxyd of chromum,
2.56 lime,
2.00 moisture or other volatile ingredient.

99.66 ‖

The *beryl* is of a greyish green colour, and sometimes blue, yellow, and even white: sometimes different colours appear in the same stone §. It is found in Ceylon, different parts of India, Brazil, and especially in Siberia and Tartary, where its crystals are sometimes a foot long ¶.

* *Hauy*, *Jour de Min.* No xxix. 71.
‡ Fig. 16.
† *Rome de Lisle*, ii. 245. and *Hauy*, *ibid.*
† *Dolomieu*, *Jour de Min.* No xxix. 1.
‡ *Ibid.*
‖ *Ann. de Chim.* xxvi. 264.
§ *Dolomieu*, *ibid.*
¶ *Ibid.*

(F) *Kirw.* I. 208.—*Karsten. Beob. der Naturf.* 5 *Band.* 71.—*Klaproth Beiträge*, I. 279. and II. 191.

(G) That is, *scale stone*, or stone composed of scales: From λεπις, *the scale of a fish*, and λιθος, *a stone*.

(H) Hence the name leucite, from λευκος, *white*.

(I) See *Jour. de Min.* No XXVII. 194. and 201. and *Klaproth's Beiträge*, II. 39.

(K) *Kir.* I. 247. and 248.—*Dolomieu. Magazin Encyclopædique*, II. 17. and 145.; and *Jour. de Min.* No XVIII. 19.—*Klaproth Beiträge*, II. 12.

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long. A fpecimen of beryl, analyfed by Vauquelin, contained

69	filica,
13	alumina,
16	glucina,
1.5	oxyd of iron.
99.5 ‖	

‖ Ann. de Chim. xxvii. 165.

It was by analyfing this ftone that Vauquelin difcovered the earth which he called *glucina*.

62 G. IX. SAB. Staurolite.

GENUS IX. SAB.

SPECIES 1. Staurolite *.

* Kirw. i. 282.

Andreolite of Lametherie and Hauy—*Hyacinthe blanche cruciforme*, var. 0. of Romé de Lifle.

This ftone has been found at Andreafberg in the Hartz. It is cryftallized, and the form of its cryftals has induced mineralogifts to give it the name of *crofsftone*. Its cryftals † are two four-fided flattened prifms, terminated by four fided pyramids, interfecting each other at right angles: the plane of interfection paffing longitudinally through the prifms (L).

† Fig. 17.

Its texture is foliated. Its luftre waxy, 2. Tranfparency from 1 to 3. Hardnefs 9. Brittle. Sp. gr. 2.355 to 2.361. Colour milk white. When heated flowly, it lofes 0.15 or 0.16 parts of its weight, and falls into powder. It effervefces with borax and microcofmic falt, and is reduced to a greenifh opaque mafs. With foda it melts into a frothy white enamel. When its powder is thrown on a hot coal, it emits a greenifh yellow light †.

† Hauy, Jour. de Min. N° xxviii. 280.

A fpecimen analyfed by Weftrum was compofed of

44	filica,
20	alumina,
20	barytes,
16	water.
100	

Klaproth found the fame ingredients, and nearly in the fame proportions ‡.

‡ Beitrage, ii. 80.

A variety of ftaurolite has been found only once, which has the following peculiarities.

Its luftre is pearly, 2. Sp. gr. 2.361. Colour brownifh grey. With foda it melts into a purplifh and yellowifh frothy enamel. It is compofed, according to Weftrum, of

47.5	filica,
12.0	alumina,
20.0	barytes,
16.0	water,
4.5	oxyds of iron and manganefe.
100.0	

63 G. X. ASL. Chryfoberyl.

GENUS X. 1. ASL.

SPECIES 1. Chryfoberyl *.

* Kirw. i. 261.

Oriental chryfolite of jewellers—*Cymophane* of Hauy.

Hitherto this ftone has been found only in Brazil, the ifland of Ceylon, and as fome affirm near Nortfchink in Siberia. Werner firft made it a diftinct fpecies, and gave it the name which we have adopted. It is ufually found in round maffes about the fize of a pea, but it is fometimes alfo cryftallized. The primitive form of its cryftals is a four-fided rectangular prifm, whofe height is to its breadth as $\sqrt{3}$ to 1, and to its thicknefs as $\sqrt{2}$ to 1 †. The only variety hitherto obferved is an eightfided prifm, terminated by fix fided fummits ‡. Two of the faces of the prifm are hexagons, two are rectangles, and four trapeziums; two faces of the fummits are rectangles, and the other four trapeziums. Sometimes two of the edges of the prifm are wanting, and fmall faces in their place †.

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† Fig. 18. ‡ Fig. 19.

† Hauy, Jour. de Min. N° xxi. 5.

Its texture is foliated. Laminæ parallel to the faces of the prifm. Luftre 3 to 4. Tranfparency 3 to 4. Caufes fingle refraction. Hardnefs 12. Sp. gr. from 3.698 ‡ to 3.7961 ‖. Colour yellowifh green, furface fparkling. It is infufible by the blow pipe *per fe*, and with foda.

‡ Werner. ‖ Hauy.

A fpecimen of chryfoberyl, analyfed by Klaproth, was compofed of

71.5	alumina,
18.0	filica,
6.0	lime,
1.5	oxyd of iron.
97.0 §	

§ Beiträge, 102.

64 G. X. 2. SAL. Hyalite.

GENUS X. 2. SAL.

SPECIES 2. Hyalite *.

* Kirw. i. 296.

This ftone is frequently found in trap. It occurs in grains, filaments, and rhomboidal maffes. Texture foliated. Fracture uneven, inclining to conchoidal. Luftre glaffy (M), 2 to 3. Tranfparency 2 to 3; fometimes, tho' feldom, it is opaque. Hardnefs 9. Sp. gr. 2.11 †. Colour pure white. Infufible at 150° Wedgewood; but it yields to foda ‡. According to Mr Link, it is compofed of

† Kirwan. ‡ Id.

57	filica,
18	alumina,
15	lime.
90	and a very little iron ‖.

‖ Crell's Annals, 1790, 2 Band. 232.

65 Ædelite.

Species 3. Ædelite *.

* Kirw. i. 276.

This ftone has hitherto been found only in Sweden at Moffeberg and Ædelfors. From this laft place Mr Kirwan, who firft made it a diftinct fpecies, has given it the name which we have adopted. It was firft mentioned by Bergman †. Its form is tuberofe and knotty. Texture ftriated; fometimes refembles quartz. Luftre from 0 to 1. Sp. gr. 2.515 after it has abforbed water ‡. Colour light grey, often tinged red; alfo yellowifh brown, yellowifh green and green. Before the blow pipe it intumefces and forms a frothy mafs. Acids convert it into a jelly §. A fpecimen from Moffeberg, analyfed by Bergman, contained

† Opufc. vi. 101. ‡ See Kirwan's Min. i. 276. § Berg. iii. 227.

69	filica,
20	alumina,
8	lime,
3	water.
100 ‖	

‖ Opufc. vi. 101.

A fpecimen from Ædelfors yielded to the fame chemift

62	filica,
18	alumina,
16	lime,
4	water.
100 ¶	

¶ Ibid.

GENUS

(L) See *Gillot*, *Jour. de Phyf.* 1792, p. 1 and 2.

(M) Hence probably the name *hyalite*, which was impofed by Werner from ὕαλος, *glafs*, and λίθος, *a ftone*.

Earths and Stones.

GENUS X. 3. SAWL.

SPECIES 4. Zeolite (N).

66 G. X. 3. SAWL. Zeolite. This stone was first described by Cronstedt in the Stockholm Transactions for 1756. It is found sometimes amorphous and sometimes crystallized. The primitive form of its crystals is a rectangular prism, whose bases are squares. The most common variety is a long four sided prism, terminated by low four sided pyramids*.

Its texture is striated or fibrous. Its lustre is silky, from 3 to 1. Transparency from 2 to 4; sometimes 1. Hardness 6 to 8; sometimes only 4. Absorbs water. Sp. gr. 2.07 to 2.3. Colour white, often with a shade of red or yellow; sometimes brick red, green, blue. When heated, it becomes electric like the tourmaline†. Before the blow-pipe it froths (O), emits a phosphorescent light, and melts into a white semitransparent enamel, too soft to cut glass, and soluble in acids. In acids it dissolves slowly and partially without effervescence; and at last, unless the quantity of liquid be too great, it is converted into a jelly.

A specimen of zeolite (P), analysed by Vauquelin, contained

53.00	silica,
27.00	alumina,
9.46	lime,
10.00	water.
99.46‡.	

SPECIES 5. Stilbite.

67 Stilbite. This stone was first formed into a distinct species by Mr Hauy. Formerly it was considered as a variety of zeolite.

The primitive form of its crystals is a rectangular prism, whose bases are rectangles. It crystallizes sometimes in dodecahedrons, consisting of a four-sided prism with hexagonal faces, terminated by four-sided summits, whose faces are oblique parallelograms; sometimes in six-sided prisms, two of whose solid angles are wanting, and a small triangular face in their place*.

Its texture is foliated. The laminæ are easily separated from each other; and are somewhat flexible. Lustre pearly, 2 or 3 (Q). Hardness inferior to that of zeolite, which scratches stilbite. Brittle. Sp. gr. 2.500†. Colour pearl white. Powder bright white, sometimes with a shade of red. This powder, when exposed to the air, cakes and adheres as if it had absorbed water. It causes syrup of violets to assume a green colour. When stilbite is heated in a porcelain crucible, it swells up and assumes the colour and semitransparency of baked porcelain. By this process it loses 0.185 of its weight. Before the blow-pipe it froths like borax, and then melts into an opaque white coloured enamel §.

According to the analysis of Vauquelin, it is composed of

52.0	silica,
17.5	alumina,
9.0	lime,
18.5	water.
97.0‖	

SPECIES 6. Analcime.

68 Analcime. This stone, which was discovered by Mr Dolomieu, is found crystallized in the cavities of lava. It was first made a distinct species by Mr Hauy. Mineralogists had formerly confounded it with zeolite.

The primitive form of its crystals is a cube. It is sometimes found crystallized in cubes, whose solid angles are wanting, and three small triangular faces in place of each; sometimes in polyhedrons with 24 faces. It is usually somewhat transparent. Hardness about 8; scratches glass slightly. Sp. gr. above 2. When rubbed, it acquires only a small degree of electricity, and with difficulty (R). Before the blow-pipe it melts without frothing, into a white semitransparent glass*.

GENUS X. 4. SLA.

SPECIES 7. Lazulite†.

69 G. X. 4. SLA. Lazulite. This stone, which is found chiefly in the northern parts of Asia, has been long known to mineralogists by the name of *lapis lazuli*. This term has been contracted into *lazulite* by Mr Hauy; an alteration which was certainly proper, and which therefore we have adopted.

Lazulite is always amorphous. Its texture is earthy. Its fracture uneven. Lustre 0. Opaque, or nearly so. Hardness 8 to 9. Sp. gr. 2.76 to 2.945‡. Colour blue (S); often spotted white from specks of quartz, and yellow from particles of pyrites.

It retains its colour at 100° Wedgewood; in a higher heat it intumesces, and melts into a yellowish black mass. With acids it effervesces a little, and if previously calcined, forms with them a jelly.

Margraff published an analysis of lazulite in the Berlin Memoirs for 1758. His analysis has since been confirmed by Klaproth, who found a specimen of it to contain

46.0	silica,
14.5	alumina,
28.0	carbonat of lime,
6.5	sulphat of lime,
3.0	oxyd of iron,
2.0	water.
100.0§	

GENUS XI. SALI.

SPECIES 1. Garnet (T).

70 G. XI. SALI. Garnet. This stone is found abundantly in many mountains. It is usually crystallized. The primitive form of its crystals

* Hauy, Jour. de Min. N° xiv. 80.

† Hauy, ibid. N° xxviii. 276.

‡ Ibid. N° xiv. 576.

* Hauy, Jour. de Min. N° xiv. 86.

† Hauy, ibid. N° xxviii. 276.

§ Vauquelin, ibid. N° xxix. 161.

‖ Ibid. 164.

* Hauy, Jour. de Min. N° xiv. 86. and xxviii. 278.

† Kirw. i. 283.

‡ Brisson.

§ Beitrage, i. 196.

(N) *Kirw.* I. 278.—*Guettard,* IV. 637.—*Bucquet, Mem. Sav. Etrang.* IX. 576.—*Pelletier, Jour. de Phys.* XX. 420.

(O) Hence the name *zeolite*, given to this mineral by Cronstedt; from ζεω, *to ferment*, and λιθος, *a stone.*

(P) Dr Black was accustomed to mention, in the course of his lectures, that Dr Hutton had discovered *soda* in zeolite. This discovery has not hitherto been verified by any other chemical mineralogist.

(Q) Hence the name given to this mineral by Hauy, *stilbite*, from στιλβω, *to shine.*

(R) Hence the name *analcime* given it by Hauy, from αναλκις, *weak.*

(S) Hence the name *lazulite*, from an Arabian word *azul*, which signifies *blue.*

(T) *Kirw.* I. 258.—*Gerhard, Disquisitio physico-chymica Granatorum,* &c.—*Pasumot, Jour. de Phys.* III. 442.—*Wiegleb, Ann. de Chim.* I. 231.

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crystals is a dodecahedron whose sides are rhombs, with angles of 70° 31' 44", and 109° 28' 16". The inclination of the rhombs to each other is 120°. This dodecahedron may be considered as a four-sided prism, terminated by four-sided pyramids *. It is divisible into four parallelopipeds, whose sides are rhombs; and each of these may be divided into four tetrahedrons, whose sides are isosceles triangles, equal and similar to either of the halves into which the rhomboidal faces of the dodecahedron are divided by their shorter diagonal. The integrant molecules of garnet are similar tetrahedrons †. Sometimes the edges of the dodecahedron are wanting, and small faces in their place; and sometimes garnet is crystallized in polyhedrons, having 24 trapezoidal faces. For a description and figure of these, and other varieties of garnet, we refer to *Romé de Lisle* and *Hauy* ‡.

* Fig. 22.
* Phil. Jour. 322 and Hauy, Ann. de Chim. xvii. 305.
† Hauy, ibid. 300.
‡ Ibid.

The texture of garnet, as Bergman first shewed, is foliated ||. Its fracture commonly conchoidal. Internal lustre from 4 to 2. Transparency from 2 to 4; sometimes only 1 or 0. Causes single refraction §. Hardness from 10 to 14. Sp. gr. 3.75 to 4.188. Colour usually red. Often attracted by the magnet. Fusible *per se* by the blow pipe.

|| Opusc. ii. 9.
§ Hauy, Jour. de Min. N° xxviii. 260.

Variety 1. Oriental garnet (u).

Internal lustre 3 to 4. Transparency 4. Hardness 13 to 14. Sp. gr. 4 to 4.188. Colour deep red, inclining to violet (x).

Variety 2. Common garnet.

Fracture uneven, inclining to the conchoidal. Internal lustre 2 to 3. Transparency from 3 to 0. Hardness 10 to 11; sometimes only 9. Sp. gr. 3.75 to 4. Colour commonly deep red, inclining to violet; sometimes verging towards black or olive; sometimes leek green, brown, yellow.

Variety 3. Amorphous garnet.

Structure flaty. Lustre 2. Transparency 2 to 1. Hardness 11 to 12. Sp. gr. 3.89. Colour brownish or blackish red. Found in Sweden, Switzerland, and the East Indies.

A specimen of oriental garnet, analysed by Klaproth, contained

35.75	silica,
27.25	alumina,
36.00	oxyd of iron,
0.25	oxyd of manganese
69.25 *	

* Beiträge, i. 26.

A specimen of red garnet, analysed by Vauquelin, contained

52.0	silica,
20.0	alumina,
17.0	oxyd of iron,
7.7	lime.
96.7 †	

† Jour. de Min. N° xliv. 575.

A specimen of black garnet yielded to the same chemist

43	silica,
16	alumina,
20	lime,
16	oxyd of iron,
4	moisture.
99 ‡.	

‡ Ibid. 577.

Mr Klaproth found a specimen of Bohemian garnet, composed of

40.00	silica,
28.50	alumina,
16.50	oxyd of iron,
10.00	magnesia,
3.50	lime,
.25	oxyd of manganese.
98.75 ¶	

Simple Stones.

¶ Beiträge, ii. 21.

SPECIES 2. Thumerstone *.

Yanolite of Lametherie—*Axinite* of Hauy.

71 Thumerstone.

This stone was first described by Mr Schreber, who found it near Balme d'Auris in Dauphiné, and gave it the name of *shorl violet* †. It was afterwards found near Thum in Saxony, in consequence of which Werner called it *thumerstone*.

* Kirw. i. 273.—Pel. Jour. de Phys. xxvi 66.
† De Lisle, ii. 353.

It is sometimes amorphous; but more commonly crystallized. The primitive form of its crystals is a rectangular prism, whose bases are parallelograms with angles of 101° 32' and 78° 28' ‡. The most usual variety is a flat rhomboidal parallelopiped, with two of its opposite edges wanting, and a small face in place of each §. The faces of the parallelopiped are generally streaked longitudinally.

‡ Hauy, Jour. de Min. N° xxviii 264.
§ Fig 21.
§ De Lisle, ibid.

The texture of thumerstone is foliated. Its fracture conchoidal. Lustre 2. Transparency, when crystallized, 3 to 4; when amorphous, 2 to 1. Causes simple refraction ||. Hardness 10 to 9. Sp gr. 3.2956. Colour clove brown; sometimes inclining to red, green, grey, violet, or black. Before the blow-pipe it froths like zeolite, and melts into a hard black enamel. With borax it exhibits the same phenomena, or even when the stone is simply heated at the end of a pincer ¶.

|| Hauy, ibid.
¶ Vauquel Jour. de Min. N° xxiii. 1.

A specimen of thumerstone, analysed by Klaproth, contained

52.7	silica,
25.6	alumina,
9.4	lime,
9.6	oxyd of iron with a trace of manganese.
97.3 *	

* Beiträge, ii. 126.

A specimen, analysed by Vauquelin, contained

44	silica,
18	alumina,
19	lime,
14	oxyd of iron,
4	oxyd of manganese.
99 †	

† Jour. de Min. ibid.

SPECIES 3. Prehnite (y).

72 Prehnite.

Though this stone had been mentioned by Sage †, Romé de Lisle *, and other mineralogists, Werner was the first who properly distinguished it from other minerals, and made it a distinct species. The specimen which he examined was brought from the Cape of Good Hope by Colonel Prehn; hence the name *prehnite*, by which he distinguished it. It was found near Dumbarton by Mr Grotche †; and since that time it has been observed in other parts of Scotland.

† Miner. i. 232.
* Crystallog. ii. 275.
† Ann. de Chim. i. 213.

It

(u) This seems to be the *carbunculus* [illegible] of Theophrastus, and the *carbunculus garamanticus* of other ancient writers. See *Hill's Theophrastus*, [illegible] p. 74 and 77.

(x) Hence, according to many, the name *garnet* (in Latin *granatus*), from the resemblance of the stone in colour to the blossoms of the pomegranate.

(y) *Kirw.* I. 274.—*Hassenfratz, Jour. de Phys.* XXXII. 81.—*Sage, ibid.* XXXIV. 446.—*Klaproth, Beob. der Berlin*, 2 *Band.* 211. And *Ann. de Chim.* I. 201.

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It is both amorphous and crystallized. The crystals are in groups, and confused: they seem to be four-sided prisms with dihedral summits ‡. Sometimes they are irregular six sided plates, and sometimes flat rhomboidal parallelopipeds.

‡ Hauy, Jour. de Min Nº xxviii. 277.

Its texture is foliated. Fracture uneven. Internal lustre pearly, scarcely 2. Transparency 3 to 2. Hardness 9 to 10. Brittle. Sp. gr. 2.6969 ||. Colour apple green, or greenish grey. Before the blow-pipe it froths more violently than zeolite, and melts into a brown enamel. A specimen of prehnite, analysed by Klaproth, was composed of

|| Hauy, ibid.

43.83	silica,
30.33	alumina,
18.33	lime,
5.66	oxyd of iron,
1.16	air and water.
99.31 §	

§ Ann. de Chim i. 213.

Whereas Mr Hassenfratz found in another specimen

50.0	silica,
20.4	alumina,
23.3	lime,
4.9	iron,
.9	water,
.5	magnesia.
100.0 ¶	

¶ Ibid and Jour. de Phys. Nº xxxii. 81.

SPECIES 4. Thallite.

73 Thallite

Green shorl of Dauphiné of De Lisle*—*Delphinite* of Saussure.

* Crystallog. ii. 401.

This stone is found in the fissures of mountains; and hitherto only in Dauphiné and on Chamouni in the Alps.

It is sometimes amorphous, and sometimes crystallized. The primitive form of its crystals is a rectangular prism, whose bases are rhombs with angles of 114° 37', and 65° 23' †. The most usual variety is an elongated four-sided prism (often flattened), terminated by four-sided incomplete pyramids §; sometimes it occurs in regular six-sided prisms ‡. The crystals are often very slender.

† Hauy, Jour. de Min Nº xxviii 271. § Fig. 12. Romé de Lisle, ibid. and Hauy, Jour de Min Nº xxx 415.

Its texture appears fibrous. Lustre inconsiderable. Transparency 2 to 3, sometimes 4; sometimes nearly opaque. Causes single refraction. Hardness 9 to 10. Brittle. Sp. gr. 3.4529 to 3.46. Colour dark green (z). Powder white or yellowish green, and feels dry. It does not become electric by heat. Before the blow-pipe, froths and melts into a black slag. With borax melts into a green bead ||.

|| Hauy, and Descotils, ibid.

A specimen of thallite, analysed by Mr Descotils, contained

37	silica,
27	alumina,
17	oxyd of iron,
14	lime,
1.5	oxyd of manganese.
96.5 §	

§ Ibid Nº xxx. 420.

GENUS XII. ALUMINA-MAGNESIA.

SPECIES 1. Cyanite*.

Sappare of Saussure.

Sappare Stones.

74 G. XII Alumina-Magnesia. Cyanite.

This stone was first described by Mr Saussure, the son, who gave it the name of *sappare* †. It is commonly found in granite rocks. The primitive form of its crystals is a four sided oblique prism, whose sides are inclined at an angle of 103°. The base forms with one side of the prism an angle of 103°; with another, an angle of 77°. It is sometimes crystallized in six sided prisms ‡.

* Kirw. i. 209.—Sage, Jour. de Phys. xxxv. 39.

† Jour de Phys. xxxiv. 213.

Its texture is foliated. Laminæ long. Fragments long, splintery. Lustre pearly, 2 to 3. Transparency of the laminæ 3. Causes single refraction ||. Hardness 6 to 9. Brittle. Sp. gr. from 3.092 to 3.622 ‡. Feels somewhat greasy. Colour milk white, with shades of sky or prussian blue (A); sometimes bluish grey; sometimes partly bluish grey, partly yellowish or greenish grey.

‡ Hauy, Jour de Min. Nº xxviii. 282.

|| Hauy, ibid.

‡ Kirwan.

Before the blow pipe it becomes almost perfectly white; but does not melt. According to the analysis of Saussure, it is composed of

66.92	alumina,
13.25	magnesia,
12.81	silica,
5.48	iron,
1.71	lime.
100.17 ¶	

¶ Jour de Phys ibid.

Cyanite has also been analysed by Struvius and Hermann, who agree with Saussure as to the ingredients; but differ widely from him and one another as to the proportions.

Struvius.		Hermann.	
6.5	- - -	30	alumina,
30.5	- - -	39	magnesia.
51.5	- - -	23	silica,
5.0	- - -	2	iron,
4.0	- - -	3	lime
96.5*		97 †	

* [illegible] † [illegible] 179 ‡ Ibid.

GENUS XII. 2. MSA.

SPECIES 2. Serpentine (B).

75 G. XII. [illegible]

This stone is found in amorphous masses. Its fracture is splintery. Lustre 0. Opaque. Hardness 6 to 7. Sp. gr. 2.2645 to 2.709. Feels rather soft, almost greasy. Generally emits an earthy smell when breathed upon. Its colours are various shades of green, yellow, red, grey, brown, blue: commonly one or two colours form the ground, and one or more appear in spots or veins (C).

Before the blow pipe it hardens and does not melt.

A specimen of serpentine, analysed by Mr Chenevix, contained

34.5	magnesia,
28.0	silica,
23.0	alumina,
4.5	oxyd of iron,
0.5	lime,
10.5	water.
101.0*	

GENUS [illegible]

(z) Hence the name *thallite* given it by Lametheric, from θαλλος, *a green leaf*.

(A) Hence the name *cyanite*, imposed by Werner.

(B) *Kirw.* I. 156.—*Margraf, Mem. Berlin*, 1759, p. 3.—*Bayen, Jour. de Phys.* XIII. 46.—*M*[illegible] *Annals*, 1789, II. 416.

(C) Hence the name *serpentine*, given to the stone from a supposed resemblance in colours to the skin of a serpent.

Earths and Stones. | Simple Stones.

76
G. XIII. MSAI. Potſtone.
† Kirw. i. 155.

GENUS XIII. MSAI.

SPECIES 1. Potſtone †.

This ſtone is found in neſts and beds, and is always amorphous. Its ſtructure is often ſlaty. Texture undulatingly foliated. Luſtre from 1 to 3. Tranſparency from 1 to 0; ſometimes 2. Hardneſs 4 to 6. Brittle. Sp. gr. from 2.8531 to 3.023. Feels greaſy. Sometimes abſorbs water. Colour grey with a ſhade of green, and ſometimes of red or yellow; ſometimes leek green; ſometimes ſpeckled with red.

Potſtone is not much affected by fire; and has therefore been made into utenſils for boiling water; hence its name.

According to Wiegleb, the potſtone of Como contains
38 magneſia,
38 ſilica,
7 alumina,
5 iron,
1 carbonat of lime,
1 fluoric acid.
———
90

77
Chlorite.
* Kirw. i. 147

SPECIES 2. Chlorite*.

This mineral enters as an ingredient into different mountains. It is ſometimes amorphous, and ſometimes cryſtallized in oblong, four ſided, acuminated cryſtals.

Its texture is foliated. Its luſtre from 0 to 2. Opaque. Hardneſs from 4 to 6; ſometimes in looſe ſcales. Colour green.

Variety 1. Farinaceous chlorite.

Compoſed of ſcales ſcarcely cohering, either heaped together, or inveſting other ſtones. Feels greaſy. Gives an earthy ſmell when breathed on. Difficult to pulveriſe. Colour graſs green; ſometimes greeniſh brown; ſometimes dark green, inclining to black. Streak white. When the powder of chlorite is expoſed to the blowpipe it becomes brown. Before the blow pipe, farinaceous chlorite froths and melts into a dark brown glaſs; with borax it forms a greeniſh brown glaſs*:

* [illegible] melin, [illegible] Nov. N° xxxix. 167.

Variety 2. Indurated chlorite.

This variety is cryſtallized. Luſtre 1. Hardneſs 6. Feel meage. Colour dark green, almoſt black. Streak mountain green.

Variety 3. Slaty chlorite.

Structure ſlaty. Fragments flatted. Internal luſtre 1 to 2. Hardneſs 5. Colour greeniſh grey, or dark green inclining to black. Streak mountain green.

A ſpecimen of the firſt variety, analyſed by Vauquelin, contained
43.3 oxyd of iron,
26.0 ſilica,
15.5 alumina,
8.0 magneſia,
2.0 muriat of potaſs,
4.0 water.
———
98.8 †

† Ann. de Chim. xxx. 106.

A ſpecimen of the ſame variety yielded Mr Høpner
12.92 oxyd of iron,
37.50 ſilica,
4.17 alumina,
43.75 magneſia,
1.66 lime.
———
100.0 ‡

‡ Sauſſure's Voyages, ii. 133.

A ſpecimen of the ſecond variety, analyſed by the ſame chemiſt, contained
10.15 oxyd of iron,
41.15 ſilica,
6.13 alumina,
39.47 magneſia,
1.50 lime,
1.50 air and water.
———
99.9 §.

§ Crell's Annals, 1790, p. 56.

On the ſuppoſition that theſe analyſes are accurate, the enormous difference between them is a demonſtration that chlorite is not a chemical combination, but a mechanical mixture.

78
G. XIV. SLAM. Siliceous ſpar.

GENUS XIV. SLAM.

SPECIES 1. Siliceous ſpar (D).

This ſtone has been found in Tranſylvania. It is cryſtallized in 4 or 6 ſided priſms, channelled tranſverſely, and generally heaped together. Its texture is fibrous. Its luſtre ſilky, 2. Its colours white, yellow, green, light blue. According to Bindheim, it contains
61.1 ſilica,
21.7 lime,
6.6 alumina,
5.0 magneſia,
1.3 oxyd of iron,
3.3 water.
———
99.0 *

* Berg. vi. 104.

79
G. XV. SAMLI. Argillite.
† Kirw. i. 234.

GENUS XV. SAMLI.

SPECIES 1. Argillite †.

Argillaceous ſchiſtus—Common ſlate.

This ſtone conſtitutes a part of many mountains.

Its ſtructure is ſlaty. Its texture foliated. Fracture ſplintery. Fragments often tabular. Luſtre moſt commonly ſilky, 2; ſometimes 0. Tranſparency from 0 to 1. Hardneſs from 5 to 8. Sp. gr. from 2.67 to 2.88. Does not adhere to the tongue. Gives a clear ſound when ſtruck. Often imbibes water. Streak white or grey. Colour moſt commonly grey, with a ſhade of blue, green, or black; ſometimes purpliſh, yellowiſh, mountain green, brown, bluiſh black; ſometimes ſtriped or ſpotted with a darker colour than the ground.

It is compoſed, according to Kirwan, of ſilica, alumina, magneſia, lime, oxyd of iron. In ſome varieties the

(D) Is this the *tremolite* of Lowitz from the lake Baikal in Siberia? If ſo, the name of the genus ought to be SLM; for he found it to contain no alumina. According to his analyſis, it was compoſed of
52 ſilica,
20 lime,
12 carbonat of lime,
12 magneſia,
———
96

The

Earths and Stones.

the lime is wanting. Several varieties contain a considerable quantity of carbonaceous matter.

Simple Stones.

Genus XVI. SLACMI.

80 G. XVI. SLACMI. Smaragdite.

SPECIES 1. Smaragdite.

This stone was called *smaragdite* by Mr Saussure, from some resemblance which it has to the emerald. Its texture is foliated. The laminæ are inflexible. Fracture even. Hardness 7. Colour in some cases fine green, in others it has the grey colour and metallic lustre of mica: it assumes all the shades of colour between these two extremes †.

According to the analysis of Vauquelin, it is composed of

50.0	silica,
13.0	lime,
11.0	alumina,
7.5	oxyd of chromum.
6.0	magnesia,
5.5	oxyd of iron,
1.5	oxyd of copper.
94.5 ‡	

† Hauy, Jour. de Min. N° xxviii, 272.

‡ Ann. de Chim. xxx. 106.

Genus XVII. SM.

81 G. XVII. SM. Kiffekil.

SPECIES 1. Kiffekil*.

Myrsen—Seafroth.

This mineral is dug up near Konie in Natolia, and is employed in forming the bowls of Turkish tobacco pipes. The sale of it supports a large monastery of dervises established near the place where it is dug. It is found in a large fissure six feet wide, in grey calcareous earth. The workmen assert, that it grows again in the fissure †, and puffs itself up like froth (E). This mineral, when fresh dug, is of the consistence of wax; it feels soft and greasy; its colour is yellow; its sp. gr. 1.600 ‡: when thrown on the fire it sweats, emits a fetid vapour, becomes hard, and perfectly white.

* Kirwan's Min. i. 144.

† Reignegg. Philos. Mag. iii. 63.

‡ Klaproth.

According to the analysis of Klaproth, it is composed of

50.50	silica,
17.25	magnesia,
25.00	water,
5.00	carbonic acid,
.50	lime.
98.25 §	

§ Beiträge, 172.

82 Steatites.

SPECIES 2. Steatites (F).

Though this mineral was noticed by the ancients, little attention was paid to it by mineralogists, till Mr Pott published his experiments on it in the Berlin Memoirs for 1747.

It is usually amorphous, but sometimes it is crystallized in six-sided prisms. Its texture is commonly earthy, but sometimes foliated. Lustre from 0 to 2. Transparency from 0 to 2. Hardness 4 to 7. Sp. gr. from 2.61 to 2.794 *. Feels greasy. Seldom adheres to the tongue. Colour usually white or grey; often with a tint of other colours; the foliated commonly green. Does not melt *per se* before the blow-pipe.

* Brisson.

Variety 1. Semi-indurated steatites.

Texture earthy. Fracture sometimes coarse splintery. Lustre 0. Transparency 0, or scarce 1. Hardness 4 to 5. Absorbs water. Takes a polish from the nail. Colour white, with a shade of grey, yellow, or green; sometimes pure white; sometimes it contains dendritical figures; and sometimes red veins.

Variety 2. Indurated steatites.

Fracture fine splintery, often mixed with imperfectly conchoidal. External lustre 2 to 1, internal 0. Transparency 2. Often has the feel of soap. Absorbs water. Colour yellowish or greenish grey; often veined or spotted with deep yellow or red.

Variety 3. Foliated or striated steatites.

The texture of this variety is usually foliated; sometimes striated. Fragments cubiform. Lustre 3. Transparency 2 to 1. Hardness 6 to 7. Colour leek green, passing into mountain green or sulphur yellow. Streak pale greenish grey. When heated to redness, it becomes grey; and at 147° Wedgewood, it forms a grey porous porcelain mass*.

* Kirwan, i. 155.

A specimen of steatites, analysed by Klaproth, contained

59.5	silica,
30.5	magnesia,
2.5	iron,
5.5	water,
98.0 †	

† Beiträge, ii. 179.

A specimen of white steatites, analysed by Mr Chenevix, contained

60.00	silica,
28.50	magnesia,
3.00	alumina,
2.50	lime,
2.25	iron.
96.25 ‡	

‡ Ann de Chim xxvi 200.

Genus XVIII. MSI.

83 G. XVIII. MSI. Chrysolite.

SPECIES 1. Chrysolite (G).

Peridot of the French—*Topaz* of the ancients.

The name *chrysolite* was applied, without discrimination, to a great variety of stones, till Werner defined it accurately, and confined it to that stone which the French chemists distinguish by the appellation of *peridot*. This stone is the *topaz* of the ancients; their chrysolite is now called *topaz* §.

§ Plinii, lib. 37. c. 8.

Chrysolite is found sometimes in unequal fragments, and sometimes crystallized †. The primitive form of its crystals is a right angled parallelopiped ‡, whose length, breadth, and thickness, are as 5, $\sqrt{8}$, $\sqrt{5}$*.

† Fig. 13.

‡ Fig. 14.

* Hauy, Jour. de Min. N° xxviii. 251.

The texture of the chrysolite is foliated. Its fracture conchoidal. Its internal lustre from 2 to 4. Its transparency from 4 to 2. Causes double refraction. Hardness

The carbonat of lime was only mechanically interposed between the fibres of the stone. See *Pallas, Neu. Nord. Beiträge*, 6 *Band*, p. 146.

(E) Hence the name *kiff-kil*, or rather *keff-kelli*, "clay froth," or "light clay."

(F) *Kirw.* I. 151.—*Pott, Mem. Berlin*, 1747, p. 57.—*Wiegleb, Jour. de Phys.* XXIX. 60.—*Lavoisier, Mem. Par.* 1778, 433.

(G) *Kirw.* I. 262.—*Cartheuser, Min.* 94.—*Dolomieu, Jour. de Min.* N° xxix. 365.—*La Metherie, Nouv. Jour. de Phys.* I. 397.

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Hardness 9 to 10. Brittle. Sp. gr. from 3.265 to 3.45. Colour green. It is infusible at 150°, but loses its transparency, and becomes blackish grey†. With borax it melts without effervescence into a transparent glass of a light green colour. Infusible with microcosmic salt ‡ and fixed alkali §.

† Kir. Min. i. 263.

‡ Vauquelin, Ann. de Chim. xxi. 97.

Variety 1. Common chrysolite.

Found in Ceylon, and South America, and in Bohemia, amidst sand and gravel ||. Lustre 3 to 1. Transparency 4 to 3. Colour yellowish green, sometimes verging to olive green, sometimes to pale yellow.

§ Kirwan ibid.

|| Lapeliert. Jour de Min. No xxii. 20.

Variety 2. Olive chrysolite—*Olivine* ¶.

Found commonly among traps and basalts; sometimes in small grains, sometimes in pretty large pieces; but it has not been observed in crystals. Lustre 2 to 3. Transparency 3 to 2. Colour olive green.

¶ Kirwan's Min. i. 263.—Le Lievre, Jour. de Phys. xxx. 397.

The first variety, according to the analysis of Klaproth, is composed of
41.5 magnesia,
38.5 silica,
19.0 oxyd of iron.

99.0†

† Klaproth's Beitrage, i. 103.

According to that of Vauquelin, it is composed of
51.5 magnesia,
38.0 silica,
9.5 oxyd of iron.

99.0‡

‡ Ann de Chim ibid.

The second variety, according to the analysis of Klaproth, is composed of
37.58 magnesia,
50.00 silica,
11.75 oxyd of iron,
.21 lime.

99.54 §.

§ Beiträge, i. 112.

84 Jade.

SPECIES 2. Jade (H).

This stone was formerly called *lapis niphriticus*, and was much celebrated for its medical virtues. It is found in Egypt, China, America, and in the Siberian and Hungarian mountains. It is sometimes adhering to rocks, and sometimes in detached round pieces.

Its surface is smooth. Its fracture splintery. External lustre 0, or scarce 1; internal waxy, 1. Transparency from 2 to 1. Hardness 10. Not brittle. Sp. gr. from 2.95 to 2.9829; or, according to Saussure, to 3.389. Feels greasy. Looks as if it had imbibed oil. Colour dark leek green, or verging towards blue; in some prominencies inclining to greenish or bluish white. When heated it becomes more transparent and brittle, but is infusible *per se*. According to Hœpfner, it is composed of
47 silica,
38 carbonat of magnesia,
9 iron,
4 alumina,
2 carbonat of lime,

100

This is the stone which the inhabitants of New Zealand make into hatchets and other cutting instruments.

G. XIX. SML.

GENUS XIX. SML.

SPECIES 1. Asbestus (I).

This mineral was well known to the ancients. They even made a kind of cloth from one of the varieties, which was famous among them for its incombustibility. It is found abundantly in most mountainous countries, and no where more abundantly than in Scotland.

It is commonly amorphous. Its texture is fibrous. Its fragments often long splintery. Lustre from 0 to 2; sometimes 3, and then it is metallic. Transparency from 0 to 2. Hardness from 3 to 7. Sp. gr. from 2.7 to 0.6806. Absorbs water. Colour usually white or green. Fusible *per se* by the blow-pipe.

Variety 1. Common asbestus.

Lustre 2 to 1. Transparency 1. Hardness 6 to 7. Sp. gr. 2.577 to 2.7. Feels somewhat greasy. Colour leek green; sometimes olive or mountain green; sometimes greenish or yellowish grey. Streak grey. Powder grey.

Variety 2. Flexible asbestus.

Amiantus.

Composed of a bundle of threads slightly cohering. Fibres flexible. Lustre 1 to 2, sometimes 3. Transparency 1 to 2, sometimes 0. Hardness 3 to 4. Sp. gr. before it absorbs water, from 0.9088 to 2.3134; after absorbing water, from 1.5662 to 2.3803†. Feels greasy. Colour greyish or greenish white; sometimes yellowish or silvery white, olive or mountain green, pale flesh red, and mountain yellow.

† Brisson.

Variety 3. Elastic asbestus.

Mountain cork.

This variety has a strong resemblance to common cork. Its fibres are interwoven. Lustre commonly 0. Opaque. Hardness 4. Sp. gr. before absorbing water, from 0.6806 to 0.9933; after absorbing water, from 1.2492 to 1.3492. Feels meagre. Yields to the fingers like cork, and is somewhat elastic. Colour white; sometimes with a shade of red or yellow; sometimes yellow or brown.

A specimen of the first variety from Dalecarlia, analysed by Bergman, contained
63.9 silica,
16.0 carbonat of magnesia,
12.8 carbonat of lime,
6.0 oxyd of iron,
1.1 alumina.

99.8 *

A specimen of the second variety yielded to the same chemist
64.0 silica,
17.2 carbonat of magnesia,
13.9 carbonat of lime,
2.7 alumina,
2.2 oxyd of iron.

100.0 †

* Opusc. iv. 170.

A specimen of the third variety contained, according to the same analysis, 56.2 silica,
26.1 carbonat of magnesia,
12.7 carbonat of lime,
3.0 iron,
2.0 alumina.

100.0 ‡

† Ibid p. 163.

‡ Ibid p. 170.

Twelve

(H) *Kirw.* I. 171.—*Bartolin, De Lapide Nephritico.*—*Lehmann, Nov. Comm. Petropol.* X. 381.—*Hœpfner, Hist. Nat. de la Suisse*, I. 251.

(I) *Kirw.* I. 159.—*Bergman*, IV. 160.—*Plot, Phil. Trans.* XV. 1051.—*Nebel, Jour. de Phys.* II. 62.—*Ibid.* III. 367.

Earths and Stones.

Twelve different specimens of asbestus, analysed by Bergman, yielded the same ingredients, differing a little in their proportions †.

† Opusc. iv.

SPECIES 2. Asbestinite (K)

86 Asbestinite. This stone is amorphous. Texture foliated or broad striated. Lustre silky, 3. Transparency 1 to 2. Hardness 5 to 6. Sp. gr. from 2.806 to 2.880. Colour white, with shades of red, yellow, green, or blue. At 150° Wedgewood it melts into a green glass.

87 G. XX. 1. SILM. Pyroxen.

GENUS XX. 1. SILM.

SPECIES 1. Pyroxen

This stone is found abundantly in lava and other volcanic productions (L). It is always crystallized. The primitive form of its crystals is an oblique angled prism, whose bases are rhombs with angles of 92° 18, and 37° 42′ ‡. It generally crystallizes in eight sided prisms, terminated by dihedral summits ||. Its texture is foliated. Hardness 9. Colour black; sometimes green. Powder greenish grey *. Commonly attracted by the magnet †. Scarcely fusible by the blow pipe ‡. With borax it melts into a yellowish glass, which appears red while it is hot §.

‡ Hauy, Jour. de Min. N° ... ii. 269.
|| De Lisle, ... 98.
* Vauquelin, Gerber.
§ Lievre.
|| Vauquelin.

According to the analysis of Vauquelin, it is composed of

52.00	silica,
14.66	oxyd of iron,
13.20	lime,
10.00	magnesia,
3.33	alumina,
2.00	oxyd of manganese.
95.19 ||	

|| Jour. de Min. N° ... x. 172.

SPECIES 2. Asbestoid *.

88 Asbestoid. This stone has obtained its name from its similarity to common asbestus. It is amorphous. Its texture is foliated or striated. Its lustre common or glassy, from 2 to 3. Transparency from 0 to 1. Hardness 6 to 7. Sp. gr. from 3 to 3.31. Colour olive or leek green; when decomposing, brown. Before the blowpipe it melts *per se* into a brown globule. With borax it forms a violet coloured globule verging towards hyacinth †. According to the analysis of Mr Macquart, it is composed of

* Kirwan, ... 46.
† Macquart, ... de ... xiii.

46	silica,
20	oxyd of iron,
11	lime,
10	oxyd of manganese,
8	magnesia.
95 ‡	

‡ Ibid.

There is a variety of this species which Kirwan calls metalliform asbestoid. Its lustre is semimetallic, 3. Opaque. Hardness 8 to 9. Sp. gr. 3.356. Colour grey, sometimes inclining to red *.

* Kirwan's ... i. 167.

Simple Stones.

GENUS XX. 2. SMIL.

SPECIES 3. Shorlaceous actinolite (M).

89 G. XX. 2. SMIL. Shorlaceous actinolite. This stone crystallizes in four or six sided prisms, thicker at one end than the other; hence it has been called by the Germans *strahlstein*, " arrow-stone." The crystals sometimes adhere longitudinally. Fracture hackly. External lustre glassy, 3 to 4; internal, 1 to 2. Transparency from 2 to 3; sometimes 1. Hardness from 7 to 10. Sp. gr. 3.023 to 3.45. Colour leek or dark green.

This stone is often the matrix of iron, copper, and tin ores.

SPECIES 5. Lamellar actinolite.

90 Lamellar actinolite. This stone resembles hornblende. It is amorphous. Texture foliated. Lustre various in different places. Transparency 0, or scarce 1. Sp. gr. 2.916. Colour dark yellowish or greenish grey.

SPECIES 6. Glassy actinolite.

91 Glassy actinolite. This stone is found amorphous, composed of fibres adhering longitudinally, or in slender four or six sided prisms. Texture fibrous. Fragments long splintery, so sharp that they can scarcely be handled without injury. External lustre glassy or silky, 3 to 4; internal 0. Transparency 2. Exceedingly brittle. Sp. gr. 2.95 to 3.493. Colour leek green; sometimes verging towards greenish or silver white; sometimes stained with yellowish or brownish red. According to Bergman it is composed of

72.0	silica,
12.7	carbonat of magnesia,
6.0	carbonat of lime,
7.0	oxyd of iron,
2.0	alumina.
99.7 *	

* Opusc. iv. 171

GENUS XXI. SL.

SPECIES 1. Shistose hornstone †.

G. XXI. SL. Shistose hornstone. The structure of this stone is slaty. Lustre from 0 to 1. Commonly opaque. Hardness 9 to 10. Sp. gr. from 2.596 to 2.641. Colour dark bluish or blackish grey. Infusible *per se*.

† Kirwan, i. 305.

Variety 1. Siliceous shistus.

Commonly intersected by reddish veins of iron stone. Fracture splintery. Lustre 0. Transparency from 0 to 1.

Variety 2. Basanite or Lydian stone.

Commonly intersected by veins of quartz. Fracture even; sometimes inclining to conchoidal. Lustre scarce 1. Hardness 10. Sp. gr. 2.596. Powder black. Colour greyish black.

This, or a stone similar to it, was used by the ancients as a touchstone. They drew the metal to be examined along the stone, and judged of its purity by the

(K) *Kirw. Min.* I. 165. Is this the *tremolite* of Werner? It certainly is not the *tremolite* of the French mineralogists.

(L) Hence the name *pyroxen* given it by Hauy; from πυρ *fire*, and ξενος, *a stranger*. It means, as he himself explains it, a *stranger in the regions of fire*. By this he means to indicate, that pyroxen, though present in lava, is not a volcanic production.

(M) In this and the following species we have followed Mr Kirwan's new arrangement exactly, without even venturing to give the synonimes of other authors. The descriptions which have been given are so many and incomplete, and the minerals themselves are still so imperfectly known, and have got so many names, that no part of mineralogy is in a state of greater confusion.

Earths and Stones.

the colour of the metallic ſtreak. On this account they called it [illegible], *the trier*. They called it alſo *Lydian ſtone*, becauſe, as Theophraſtus informs us, it was found moſt abundantly in the river Tmolus in Lydia†. A ſpecimen of the firſt variety, analyſed by Wiegleb, contained

75.0	ſilica,
10.0	lime,
4.6	magneſia,
3.5	iron,
5.2	carbon.
98.3	

† Hill's Theophraſtus, [illegible] p. 192.

This ſpecies is rather a mechanical mixture than a chemical combination.

93 G. XXII. Zs. Zircon.

Genus XXII. Zs.

Species 1. Zircon*.

Jargon—Hyacinth.

* Kirwan, i. 257. and 333.

This ſtone is brought from Ceylon, and found alſo in France, Spain, and other parts of Europe. It is commonly cryſtallized. The primitive form of its cryſtals is an octahedron§, compoſed of two four-ſided pyramids applied baſe to baſe, whoſe ſides are iſoſceles triangles (N). The inclination of the ſides of the ſame pyramid to each other is 124° 12′; the inclination of the ſides of one pyramid to thoſe of another 82° 50′. The ſolid angle at the apex is 73° 44′†. The varieties of the cryſtalline forms of zircon amount to ſeven. In ſome caſes there is a four ſided priſm interpoſed between the pyramids of the primitive form; ſometimes all the angles of this priſm are wanting, and two ſmall triangular faces in place of each; ſometimes the cryſtals are dodecahedrons, compoſed of a flat four-ſided priſm with hexagonal faces, terminated by four-ſided ſummits with rhomboidal faces‖; ſometimes the edges of this priſm, ſometimes the edges where the priſm and ſummit join, and ſometimes both together, are wanting, and we find ſmall faces in their place. For an accurate deſcription and figure of theſe varieties, we refer to *Mr Hauy*‡.

§ Fig. 25.

† Hauy. Jour. de Min. N° xxvi. 91.

‖ Fig. 26.

‡ Ibid.

The texture of the zircon is foliated. Internal luſtre 3. Tranſparency from 4 to 2. Cauſes a very great double refraction. Hardneſs from 10 to 16. Sp. gr. from 4.2 to 4.165†. Colour commonly reddiſh or yellowiſh; ſometimes it is limpid.

† Ibid.

Before the blow pipe it loſes its colour, but not its tranſparency. With borax it melts into a tranſparent glaſs. Infuſible with fixed alkali and microcoſmic ſalt.

1. The variety formerly called *hyacinth* is of a yellowiſh red colour, mixed with brown. Its ſurface is ſmooth. Its luſtre 3. Its tranſparency 3 to 4.

2. The variety formerly called *jargon of Ceylon*, is either grey, greeniſh, yellowiſh brown, reddiſh brown, or violet. It has little external luſtre. Is ſometimes nearly opaque.

The firſt variety, according to the analyſis of Vauquelin, is compoſed of

64.5	zirconia,
32.0	ſilica,
2.0	oxyd of iron.
98.5†	

† Ibid. p. 106.

Saline Stones.

A ſpecimen analyſed by Klaproth contained

70.0	zirconia,
25.0	ſilica,
0.5	oxyd of iron.
95.5‡	

‡ Beiträge, i. 231.

The ſecond variety, according to Klaproth, who diſcovered the component parts of both theſe ſtones, contains

68.0	zirconia,
31.5	ſilica,
0.5	nickel and iron.
100.0§	

§ Ibid. i. 219.

Order II. SALINE STONES.

Under this order we comprehend all the minerals which conſiſt of an earthy baſis combined with an acid. They naturally divide themſelves into five genera. We ſhall deſcribe them in the following order. 94 Genera.

I. Calcareous salts.
- Carbonat of lime,
- Sulphat of lime,
- Phoſphat of lime,
- Fluat of lime,
- Borat of lime.

II. Barytic salts.
- Carbonat of barytes,
- Sulphat of barytes.

III. Strontitic salts.
- Carbonat of ſtrontites,
- Sulphat of ſtrontites.

IV. Magnesian salts.
- Sulphat of magneſia.

V. Aluminous salts.
- Alum.

Genus I. Calcareous salts. 95 G. I. Calcareous ſalts.

This genus comprehends all the combinations of lime and acids which form a part of the mineral kingdom.

Species 1. Carbonat of lime. 96 Carbonat of lime.

No other mineral can be compared with carbonat of lime in the abundance with which it is ſcattered over the earth. Many mountains conſiſt of it entirely, and hardly a country is to be found on the face of the globe, where, under the names of limeſtone, chalk, marble, ſpar, it does not conſtitute a greater or ſmaller part of the mineral riches.

It is often amorphous, often ſtalactitical, and often cryſtallized. The primitive form of its cryſtals is a parallelopiped, whoſe ſides are rhombs, with angles of 77° 30′ and 102° 30′‡. Its integrant molecules have the ſame form. The varieties of its cryſtals amount to more than 40; for a deſcription and figure of which we refer to *Romé de Liſle** and *Hauy* (O).

‡ Fig. 28.

* Cryſtal. i. 497.

When cryſtallized, its texture is foliated; when amorphous, its ſtructure is ſometimes foliated, ſometimes ſtriated, ſometimes granular, and ſometimes earthy. Its luſtre

(N) Let ABC (fig. 27.) be one of the ſides. Draw the perpendicular BD; then AB = 5, BD = 4, AD = 3.

(O) *Eſſai d'une Theorie*, &c. p. 75.—*Jour. de Phyſ.* 1793, Auguſt, p. 114.—*Jour. d'Hiſt. Nat.* 1792, February, p. 148.—*Ann. de Chim.* XVII. 249. &c.—*Jour de Min.* N° XXVIII. 304.

Earths and Stones. lustre varies from 0 to 3. Transparency from 0 to 4. It causes double refraction; and it is the only mineral which causes double refraction through two parallel faces of the crystal. Hardness from 3 to 9. Sp. gr. from 2.315 to 2.78. Colour, when pure, white. Effervesces violently with muriatic acid, and dissolves completely, or leaves but a small residuum. The solution is colourless.

This species occurs in a great variety of forms; and therefore has been subdivided into numerous varieties. All these may be conveniently arranged under two general divisions.

I. Soft carbonat of lime.

Variety 1. Agaric mineral.

Mountain milk, or *mountain meal* of the Germans.

This variety is found in the clefts of rocks, or the bottom of lakes. It is nearly in the state of powder; of a white colour, sometimes with a shade of yellow; and so light, that it almost floats on water.

Variety 2. Chalk.

The colour of chalk is white, sometimes with a shade of yellow. Lustre 0. Opaque. Hardness 3 to 4. Sp. gr. from 2.315 to 2.657. Texture earthy. Adheres slightly to the tongue. Feels dry. Stains the fingers, and marks. Falls to powder in water. It generally contains about $\frac{2}{100}$ of alumina, and $\frac{2}{100}$ of water; the rest is carbonat of lime.

Variety 3. Arenaceous limestone.

Colour yellowish white. Lustre 1. Transparency 1. So brittle, that small pieces crumble to powder between the fingers. Sp. gr. 2.742. Phosphoresces in the dark when scraped with a knife, but not when heated. It consists almost entirely of pure carbonat of lime.

Variety 4. Testaceous tufa.

The colour of this variety is yellowish or greyish white. It is exceedingly porous and brittle; and is either composed of broken shells, or resembles mortar containing shells; or it consists of fistulous concretions variously ramified, and resembling moss.

II. Indurated carbonat of lime.

Variety 1. Compact limestone.

The texture of this variety is compact. It has little lustre; and is most commonly opaque. Hardness 5 to 8. Sp. gr. 1.3864 to 2.72. Colour grey, with various shades of other colours. It most commonly contains about $\frac{1}{12}$th of alumina, oxyd of iron, &c.; the rest is carbonat of lime. This variety is usually burnt as lime.

Variety 2. Granularly foliated limestone.

Structure sometimes slaty. Texture foliated and granular. Lustre 2 to 1. Transparency 2 to 1. Hardness 7 to 8. Sp. gr. 2.71 to 2.8376. Colour white, of various shades from other colours.

Variety 3. Sparry limestone.

Structure sparry. Texture foliated. Fragments rhomboidal. Lustre 2 to 3. Transparency from 2 to 4; sometimes 1. Hardness 5 to 6. Sp. gr. from 2.693 to 2.718. Colour white: often with various shades of other colours. To this variety belong all the crystals of carbonat of lime.

Variety 4. Striated limestone.

Texture striated or fibrous. Lustre 1 to 0. Transparency 2 to 1. Hardness 5 to 7. Sp. gr. commonly from 2.6 to 2.77. Colours various.

Variety 5. Swine stone.

Saline Stones. Texture often earthy. Fracture often splintery. Lustre 1 to 0. Transparency 0 to 1. Hardness 6 to 7. Sp. gr. 2.701 to 2.7121. Colour dark grey, of various shades. When scraped or pounded, it emits an urinous or garlic smell.

Variety 6. Oviform.

This variety consists of a number of small round bodies, closely compacted together. Lustre 0. Transparency 0 or 1. Hardness 6 to 7.

SPECIES 2. Sulphat of lime. 97 Sulphat of lime.

Gypsum—Selenite.

This mineral is found abundantly in Germany, France, England, Italy, &c.

It is found sometimes in amorphous masses, sometimes in powder, and sometimes crystallized. The primitive form of its crystals, according to Romé de Lisle, is a decahedron ‡, which may be conceived as two four-sided pyramids, applied base to base, and which, instead of terminating in pointed summits, are truncated near their bases; so that the sides of the pyramids are trapeziums, and they terminate each in a rhomb. These rhombs are the largest faces of the crystal. The angles of the rhombs are 52° and 158°. The inclination of two opposite faces of one pyramid to the two similar faces of the other pyramid is 145°, that of the other faces 110° *. Sometimes some of the faces are elongated: sometimes it crystallizes in six-sided prisms, terminated by three or four sided summits, or by an indeterminate number of curvilinear faces. For a description and figure of these varieties, we refer to *Romé de Lisle* †.

‡ Fig. 29.

* *Crystal.* 144.

† *Ibid.*

The texture of sulphat of lime is most commonly foliated. Lustre from 0 to 4. Transparency from 0 to 4. It causes double refraction. Its hardness does not exceed 4. Its sp. gr. from 1.872 to 2.311. Colour commonly white or grey.

Before the blow-pipe, it melts into a white enamel, provided the blue flame be made to play upon the edges of its laminæ. When the flame is directed against its faces, the mineral falls into powder †.

† *Le Lievre, Jour de Min*, N° xxviii. 315.

It does not effervesce with muriatic acid, except it be impure; and it does not dissolve in it.

The following varieties of this mineral are deserving of attention.

Variety 1. Broad foliated sulphat.

Texture broad foliated. Lustre glassy, from 4 to 2. Transparency from 4 to 3. Hardness 4. Sp. gr. 2.311. Colour grey, often with a shade of yellow.

Variety 2. Grano-foliated sulphat.

Texture foliated, and at the same time granular; so that it easily crumbles into powder. Lustre 2 to 3. Transparency 2 to 3. Hardness 4 to 3. Sp.gr. from 2.274 to 2.310. Feels soft. Colour white or grey, often with a tinge of yellow, blue, or green; sometimes flesh red, brown, or olive green.

Variety 3. Fibrous sulphat.

Texture fibrous. Fragments long splintery. Lustre 2 to 3. Transparency 2 to 1; sometimes 3. Hardness 4. Brittle. Sp. gr. 2.300. Colour white, often with a shade of grey, yellow, or red; sometimes flesh red, and sometimes honey yellow; sometimes several of these colours meet in stripes.

Variety 4. Compact sulphat.

Texture compact. Lustre 1 or 0. Transparency 2 to

1,

1, sometimes – Hardness 4. Sp. gr. from 1.872 to 2.288. Feels dry, but not harsh. Colour white, with a shade of grey, yellow, blue, or green: sometimes yellow; sometimes red; sometimes spotted, striped, or veined.

Variety 5. Farinaceous sulphat.

Of the consistence of meal. Lustre 0. Opaque. Scarcely sinks in water. Is not gritty between the teeth. Feels dry and meagre. Colour white. When heated below redness, it becomes of a dazzling white.

95 Phosphat of lime.

SPECIES 3. Phosphat of lime.

Apatite – *Phosphorite* – *Chrysolite*—of the French.

This substance is found in Spain, where it forms whole mountains, and in different parts of Germany. It is sometimes amorphous, and sometimes crystallized. The primitive form of its crystals is a regular six-sided prism ‡. Its integrant molecule is a regular triangular prism, whose height is to a side of its base as 1 to $\sqrt{2}$ §. Sometimes the edges of the primitive hexagonal prism are wanting, and small faces in their place; sometimes there are small faces instead of the edges which terminate the prism; sometimes these two varieties are united; sometimes the terminating edges and the angles of the prism are replaced by small faces †; and sometimes the prism is terminated by four-sided pyramids *.

‡ Fig. 30.

§ *Hauy, Jour. de Min* N° xxviii p. 310.

† Fig. 31

* *Hauy, ibid.*

Its texture is foliated. Its fracture uneven, tending to conchoidal. External lustre from 2 to 3, internal 3 to 2. Transparency from 4 to 2. Causes single refraction. Hardness 6 to 7. Brittle. Sp. gr. from 2.8249 to 3.218. Colour commonly green or grey; sometimes brown, red, blue, and even purple.

It is infusible by the blow-pipe. When its powder is thrown upon burning coals, it emits a yellowish green phosphorescent light. It is soluble in muriatic acid without effervescence or decomposition, and the solution often becomes gelatinous.

99 Fluat of lime.

SPECIES 4. Fluat of lime.

Fluor.

This mineral is found abundantly in different countries, particularly in Derbyshire. It is both amorphous and crystallized.

The primitive form of its crystals is the regular octohedron; that of its integrant molecules the regular tetrahedron *. The varieties of its crystals hitherto observed amount to 7. These are the primitive octohedron; the cube; the rhomboidal dodecahedron; the cubo octohedron †, which has both the faces of the cube and of the octohedron; the octohedron wanting the edges; the cube wanting the edges, and either one face ‡, or two faces in place of each. For a description and figure of these we refer to *Mr Hauy* †.

* *Hauy, ibid* p. 325.

† Fig. 32.

‡ Fig. 33.

† *Ibid.*

The texture of fluat of lime is foliated. Lustre from 2 to 3, sometimes 0. Transparency from 2 to 4, sometimes 1. Causes single refraction. Hardness 8. Very brittle. Sp gr. from 3.0943 to 3.1911. Colours numerous, red, violet, green, red yellow, blackish purple. Its powder thrown upon hot coals emits a bluish or greenish light. Two pieces of it rubbed in the dark phosphoresce. It decrepitates when heated. Before the blow-pipe it melts into a transparent glass ‡.

‡ *Ibid.*

It admits of a polish, and is often formed into vases and other ornaments.

100 Borat of lime.

SPECIES 5. Borat of lime.

Boracite

This mineral has been found at Kalkberg near Luneburg, seated in a bed of sulphat of lime. It is crystallized. The primitive form of its crystals is the cube §. In general, all the edges and angles of the cube are truncated; sometimes, however, only the alternate angles are truncated *. The size of the crystals does not exceed half an inch.

§ *Hauy, Jour. de Min.* N° xxv i p. 325

* *Hauy* and *Westrum.*

The texture of this mineral is compact. Its fracture is flat conchoidal. External lustre 3; internal, greasy, 2. Transparency from 2 to 3. Hardness 9 to 10. Sp. gr. 2.566. Colour greyish white, sometimes passing into greenish white or purplish.

When heated it becomes electric; and the angles of the cube are alternately positive and negative †.

† *Hauy, ibid.* and *Ann. de Chim.* ix. 59.

Before the blow-pipe it froths, emits a greenish light, and is converted into a yellowish enamel, garnished with small points, which, if the heat be continued, dart out in sparks ‖.

‖ *Le Lievre, Jour. de Min. ibid.*

According to Westrum, who discovered its component parts, it contains

68	boracic acid,
13.5	magnesia,
11	lime,
1	alumina,
2	silica,
1	iron.
96 §	

§ *Ann. de Chim.* ii. 116.

SPECIES 6. Nitrat of lime.

101 Nitrat of lime.

Found abundantly mixed with native nitre. For a description see the article CHEMISTRY in this *Supplement*, n° 672.

102 Genus II. Barytic salts.

GENUS II. BARYTIC SALTS.

This genus comprehends the combinations of barytes with acids.

103 Carbonat of barytes.

SPECIES 1. Carbonat of barytes.

Witherite.

This mineral was discovered by Dr Withering; hence Werner has given it the name of *witherite*. It is found both amorphous and crystallized. The crystals are octohedrons or dodecahedrons, consisting of four or six sided pyramids applied base to base; sometimes the six-sided pyramids are separated by a prism; sometimes several of these prisms are joined together in the form of a star.

Its texture is fibrous. Its fracture conchoidal. Its fragments long splintery. Lustre 2. Transparency 2 to 3. Hardness 5 to 6. Brittle. Sp. gr. 4.3 to 4.338. Colour greenish white. When heated it becomes opaque. Its powder phosphoresces when thrown on burning coals *.

* *Hauy.*

It is soluble with effervescence in muriatic acid. The solution is colourless.

According to Pelletier it contains

62	barytes,
22	carbonic acid,
16	water.
100 †	

† *Jour. de Min.* N° xxi. p 46.

104 Sulphat of barytes.

SPECIES 2. Sulphat of barytes.

Borosélenite.

This mineral is found abundantly in many countries, particularly in Britain. It is sometimes in powder, often in amorphous masses, and often crystallized. The primitive form of its crystals is a rectangular prism, whose

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whose bases are rhombs, with angles of 101° 30' and 78° 30' ‡. The varieties of its crystals are very numerous. For a description and figure of them we refer to *Rom de Lisle* || and *Hauy* *. The most common varieties are the octohedron with cuneiform summits, the six or four sided prism, the hexangular table with bevelled edges. Sometimes these crystals are needle form.

Its texture is commonly foliated. Lustre from 0 to 2. Transparency from 2 to 0; in some cases 3 or 4. Hardness from 5 to 6. Sp. gr. from 4.4 to 4.44. Colour commonly white, with a shade of yellow, red, blue, or brown.

‡ *Hauy, Ess. d'une Theorie*, &c. p. 119.

|| *Crystal.* i. 588.

* *Ibid.* and *Ann de Chim* xii. 3.

When heated it decrepitates. It is fusible *per se* by the blue flame of the blow-pipe, and is converted into sulphuret of barytes. Soluble in no acid except the sulphuric; and precipitated from it by water.

Variety 1. Foliated sulphat.

Lustre 3 to 3. Transparency from 4 to 2, sometimes 1. Colours white, reddish, bluish, yellowish, blackish, greenish. Mr Werner subdivides this variety into three, according to the nature of the texture. These three subdivisions are *granularly foliated*, *straight foliated*, *curve foliated*.

Variety 2. Fibrous sulphat.

Texture fibrous; fibres converging to a common centre. Lustre silky or waxy, 2. Transparency 2 to 1. Hardness 5. Colours yellowish, bluish, reddish.

Variety 3. Compact sulphat.

Texture compact, Lustre 0 to 1. Transparency 1 to 0. Feels meagre. Almost constantly impure. Colours light yellow, red, or blue.

Variety 4. Earthy sulphat.

In the form of coarse dusty particles, slightly cohering. Colour reddish or yellowish white.

105 G. III. Strontitic Salts.

GENUS III. STRONTITIC SALTS.

This genus comprehends all the combinations of strontites and acids which form a part of the mineral kingdom.

106 Carbonat of strontites.

SPECIES 1. Carbonat of strontites.

This mineral was first discovered in the lead mine of Strontion in Argyleshire; and since that time it is said to have been discovered, though not in great abundance, in other countries. It is found amorphous, and also crystallized in needles, which, according to Hauy, are regular six sided prisms.

Its texture is fibrous; the fibres converge. Fracture uneven. Lustre 2. Transparency 2. Hardness 5. Sp. gr. from 3.4 to 3.66. Colour light green. Does not decrepitate when heated. Before the blow pipe becomes opaque and white, but does not melt. With borax it effervesces, and melts into a transparent colourless glass. Effervesces with muriatic acid, and is totally dissolved. The solution tinges flame purple.

107 Sulphat of strontites.

SPECIES 2. Sulphat of strontites.

Celestine.

This mineral has been found in Pennsylvania, in Germany, in France, in Sicily, and Britain. It was first discovered near Bristol by Mr Clayfield. There it is found in such abundance, that it has been employed in mending the roads.

It occurs both amorphous and crystallized. The crystals are most commonly bevelled tables, sometimes rhomboidal cubes. Its texture is foliated. More or less transparent. Hardness 5. Sp. gr. from 3.51 to 3.96. Colour most commonly a fine sky blue; sometimes reddish; sometimes white, or nearly colourless *.

Aggregates.

* *Cl. of M. Nicholson's Jour.* iii. 56.

Klaproth found a specimen of this mineral from Pennsylvania composed of

58 strontites,
42 sulphuric acid.

100 †

† *Beiträge*, ii. 97.

According to the analysis of Mr Clayfield, the sulphat of strontites found near Bristol is composed of

58.25 strontites,
41.75 sulphuric acid of 2.24, and a little iron ‡.

100.00

‡ *Ibid. Nicholson's Journal.*

According to the analysis of Vauquelin, the sulphat of strontites found at Bouvron in France, which was contaminated with .1 of carbonat of lime, is composed of

54 strontites,
45 sulphuric acid.

99 §

§ *Jour. de Min.* N° xxxvii. 6.

108 G. IV. Magnesian Salts.

GENUS IV. MAGNESIAN SALTS.

This genus comprehends the combinations of magnesia and acids which occur in the mineral kingdom. Only two species have hitherto been found; namely,

109 Sulphat of magnesia.

SPECIES 1. Sulphat of magnesia.

It is found in Spain, Bohemia, Britain, &c.; and enters into the composition of many mineral waters. For a description of it, we refer to CHEMISTRY, n° 633. in this *Suppl.*

110 Nitrat of magnesia.

SPECIES 2. Nitrat of magnesia.

Found sometimes associated with nitre. For a description see CHEMISTRY, n° 674.

111 G. V. Aluminous salts.

GENUS V. ALUMINOUS SALTS.

This genus comprehends those combinations of alumina and acids which occur in the mineral kingdom.

112 Alum.

SPECIES 1. Alum.

This salt is found in crystals, in soft masses, in flakes, and invisibly mixed with the soil. For a description, we refer to CHEMISTRY, n° 636.

ORDER III. AGGREGATES.

THIS order comprehends all mechanical mixtures of earths and stones found in the mineral kingdom. These are exceedingly numerous: the mountains and hills, the mould on which vegetables grow, and indeed the greater part of the globe, may be considered as composed of them. A complete description of aggregates belongs rather to geology than mineralogy. It would be improper, therefore, to treat of them fully here. But they cannot be altogether omitted; because aggregates are the first substances which present themselves to the view of the practical mineralogist, and because, without being acquainted with the names and component parts of many of them, the most valuable mineralogical works could not be understood.

113 Divisions of aggregates.

Aggregates may be comprehended under four divisions: 1. Mixtures of earths; 2. Amorphous fragments of stones agglutinated together; 3. Crystallized stones, either agglutinated together or with amorphous stones; 4. Aggregates formed by fire. It will be exceedingly convenient

Earth and Stones. convenient to treat each of these separately. We shall therefore divide this order into four sections.

Sect. I. *Aggregates of Earths.*

The most common earthy aggregates may be comprehended under the following genera:

1. Clay,
2. Colorific earths,
3. Marl,
4. Mould.

114 Clay.

Genus I. Clay.

Clay is a mixture of alumina and silica in various proportions. The alumina is in a state of an impalpable powder; but the silica is almost always in small stones, large enough to be distinguished by the eye. Clay, therefore, exhibits the character of alumina, and not of silica, even when this last ingredient predominates. The particles of silica are already combined with each other; and they have so strong an affinity for each other, that few bodies can separate them; whereas the alumina, not being combined, readily displays the characters which distinguish it from other bodies. Besides alumina and silica, clay often contains carbonat of lime, of magnesia, barytes, oxyd of iron, &c. And as clay is merely a mechanical mixture, the proportion of its ingredients is exceedingly various.

Clay has been divided into the following species:

115 Porcelain clay.

Species 1. Porcelain clay.

Its texture is earthy. Its lustre 0. Opaque. Hardness 4. Sp. gr. from 2.23 to 2.4. Colour white, sometimes with a shade of yellow or red. Adheres slightly to the tongue. Feels soft. Falls to powder in water.

A specimen, analysed by Hassenfratz, contained

62 silica,
19 alumina,
12 magnesia,
7 sulphat of barytes.

———

100 *

A specimen, analysed by Mr Wedgewood, contained

60 alumina,
20 silica,
12 air of water.

———

92

116 Common clay.

Species 2. Common clay.

Its texture is earthy. Lustre 0. Opaque. Hardness 3 to 6. Sp. gr. 1.8 to 2.68. Adheres slightly to the tongue. Often feels greasy. Falls to powder in water. Colour, when pure, white; often tinged blue or yellow.

Variety 1. Potter's clay.

Hardness 3 to 4. Sp. gr. 1.8 to 2. Stains the fingers slightly. Acquires some polish by friction. Colour white; often with a tinge of yellow or blue; sometimes brownish, greenish, reddish. Totally diffusible in water; and, when duly moistened, very ductile.

Variety 2. Indurated clay.

Hardness 5 to 6. Does not diffuse itself in water, but falls to powder. Discovers but little ductility. Colours grey, yellowish, bluish, greenish, reddish, brownish.

* *Ann. de Chim.* xiv. 144.

Variety 3. Shistose clay.

Structure slaty. Sp. gr. from 2.6 to 2.68. Feels smooth. Streak white or grey. Colour commonly bluish, or yellowish grey; sometimes blackish, reddish, greenish. Found in strata, usually in coal mines.

This variety is sometimes impregnated with bitumen. It is then called bituminous *shale*.

Species 3. Lithomarga. 117 Lithomarga.

Texture earthy. Fracture conchoidal. Lustre from 0 to 2. Opaque. Hardness 3 to 7. Sp. gr. when pretty hard, 2.815. Surface smooth, and feels soapy. Adheres strongly to the tongue. Falls to pieces, and then to powder, in water; but does not diffuse itself through that liquid. Fusible *per se* into a frothy mass.

Variety 1. Friable lithomarga.

Formed of scaly particles slightly cohering. Lustre 1 to 0. Hardness 3 to 4. Exceedingly light. Feels very smooth, and assumes a polish from the nail. Colour white; sometimes tinged yellow or red.

Variety 2. Indurated lithomarga.

Hardness 4 to 7. The softer sorts adhere very strongly to the tongue when newly broken; the harder very moderately. Colours grey, yellow, red, brown, blue.

A specimen of lithomarga from Osmund, analysed by Bergman, contained

60.0 silica,
11.0 alumina,
5.7 carbonat of lime,
4.7 oxyd of iron,
0.5 carbonat of magnesia,
18.0 water and air.

———

99.9 †

† *Opusc.* iv.

Species 4. Bole. 118 Bole.

Texture earthy. Fracture conchoidal. Lustre 0. Transparency scarce 1. Hardness 4. Sp. gr. from 1.4 to 2. Acquires a polish by friction. Scarcely adheres to the tongue. Feels greasy. Colour yellow or brown; sometimes red; sometimes spotted.

The lemnian earth which belongs to this species, according to the analysis of Bergman, contains

47.0 silica,
19.0 alumina,
6.0 carbonat of magnesia,
5.4 carbonat of lime,
5.4 oxyd of iron,
17.0 water and air.

———

99.8 ‡

‡ *Ibid*, p. 157.

Species 5. Fullers earth. 119 Fullers earth.

Texture earthy. Structure sometimes slaty. Fracture imperfectly conchoidal. Lustre 0. Opaque. Hardness 4. Receives a polish from friction. Does not adhere to the tongue. Feels greasy. Colour usually light green.

A specimen from Hampshire, analysed by Bergman, contained

51.8 silica,
25.0 alumina,
3.3 carbonat of lime,
3.7 oxyd of iron,
0.7 carbonat of magnesia,
15.5 moisture.

———

100.0 §

§ *Ibid*, 159.

This

Earths and Stones.

This earth is used by fullers to take the grease out of their cloth before they apply soap. It is essential to fullers earth that the particles of silica be very fine, otherwise they would cut the cloth. Any clay, possessed of this last property, may be considered as *fullers earth*; for it is the alumina alone which acts upon the cloth, on account of its strong affinity for greasy substances.

120 G. II. Colorific earths.

GENUS II. COLORIFIC EARTHS.

The minerals belonging to this genus consist of clay, mixed with so large a quantity of some colouring ingredient as to render them useful as paints. The colouring matter is commonly oxyd of iron, and sometimes charcoal.

121 Red chalk.

SPECIES 1. Red chalk.

Reddle.

Texture earthy. Fracture conchoidal. Lustre 0. Opaque. Hardness 4. Sp. gr. inconsiderable. Colour dark red.

Feels rough. Stains the fingers. Adheres to the tongue. Falls to powder in water. Does not become ductile. When heated it becomes black, and at 159° Wedgewood melts into a greenish yellow frothy enamel.

Composed of clay and oxyd of iron.

122 Yellow chalk.

SPECIES 2. Yellow chalk.

Texture earthy. Fracture conchoidal. Hardness 3. Sp. gr inconsiderable. Colour ochre yellow.

Feels smooth or greasy. Stains the fingers. Adheres to the tongue. Falls to pieces in water. When heated becomes red; and at 156° Wedgewood melts into a brown porous porcelain.

According to Sage, it contains

50 alumina,
40 oxyd of iron,
10 water, with some sulphuric acid.

100 *

* Mem. Par. 1779, 313.

123 Black chalk.

SPECIES 3. Black chalk.

Structure slaty. Texture earthy. Fragments splintery. Lustre 0. Opaque. Hardness 5. Sp. gr. 2.144 to 2.277. Colour black. Streak black.

Feels smooth. Adheres slightly to the tongue. Does not moulder in water. When heated to redness it becomes reddish grey.

According to Wiegleb, it is composed of

64.50 silica,
11.25 alumina,
11.00 charcoal,
2.75 oxyd of iron,
7.50 water.

97.00 †

† Ann. de Chim. xxx. 13.

124 Green earth.

SPECIES 4. Green earth.

Texture earthy. Lustre 0. Opaque. Hardness 6 to 7. Sp gr. 2.637. Colour green.

Commonly feels smooth. Does not stain the fingers. Often falls to powder in water. When heated it becomes reddish brown; and at 147° Wedgewood melts into a black compact glass.

Composed of clay, oxyds of iron and nickel.

125 G. III. Marl.

GENUS III. MARL.

A mixture of carbonat of lime and clay, in which the carbonat considerably exceeds the other ingredient, is called *marl*. Aggregates.

Its texture is earthy. Lustre 0. Opaque. Hardness from 4 to 8; sometimes in powder. Sp. gr. from 1.6 to 2.877. Colour usually grey, often tinged with other colours. Effervesces with acids.

Some marls crumble into powder when exposed to the air; others retain their hardness for many years.

Marls may be divided into two species: 1. Those which contain more silica than alumina; 2. Those which contain more alumina than silica. Mr Kirwan has called the first of these *siliceous*, the second *argillaceous*, marls. Attention should be paid to this distinction when marls are used as a manure.

GENUS IV. MOULD. 126 G. IV. Mould.

By *mould* is meant the soil on which vegetables grow.

It contains the following ingredients: silica, alumina, lime, magnesia (sometimes), iron, carbon derived from decayed vegetable and animal substances, carbonic acid, and water. And the good or bad qualities of *soils* depends upon a proper mixture of these ingredients. The silica is seldom in the state of an impalpable powder, but in grains of a greater or smaller size: Its chief use seems to be to keep the soil open and pervious to moisture. If we pass over the carbon, the iron, and the carbonic acid, the goodness of a soil depends upon its being able to retain the quantity of moisture which is proper for the nourishment of vegetables, and no more. Now the retentive power of a soil increases with the proportion of its alumina, lime, or magnesia, and diminishes as the proportion of its silica increases. Hence it follows, that in a dry country, a fertile soil should contain less silica, and more of the other earths, than in a wet country.

Giobert found a fertile soil near Turin, where it rains annually 30 inches, to contain

From 77 to 79 silica,
9 — 14 alumina,
5 — 12 lime.

Near Paris, where it rains about 20 inches annually, Mr Tillet found a fertile soil to contain

Coarse sand 25
Fine sand 21
— 46.0 silica,
16.5 alumina,
37.5 lime.

100.0 ‡

‡ Kirwan on Manures.

The varieties of mould are too numerous to admit an accurate description: we shall content ourselves, therefore, with mentioning the most remarkable.

SPECIES 1. Sand. 127 Sand.

This consists of small grains of siliceous stones not cohering together, nor softened by water. When the grains are of a large size, the soil is called *gravel*.

SPECIES 2. Clay. 128 Clay.

This consists of common clay mixed with decayed vegetable and animal substances.

SPECIES 3. Loam. 129 Loam.

Any soil which does not cohere so strongly as clay, but more strongly than chalk, is called *loam*. There are many varieties of it. The following are the most common.

Earth and Stones.

Variety 1. Clayey loam; called alſo *ſtrong*, *ſtiff*, *cold*, and *heavy*, loam.

It conſiſts of a mixture of clay and coarſe ſand.

Variety 2. Chalky loam.

A mixture of clay, chalk, and coarſe ſand; the chalk predominating.

Variety 3. Sandy loam.

A mixture of the ſame ingredients; the ſand amounting to .8 or .9 of the whole.

130 Till.

SPECIES 4. Till.

Till is a mixture of clay and oxyd of iron. It is of a red colour, very hard and heavy.

SECT. II. *Aggregates of amorphous ſtones.*

THE aggregates which belong to this ſection conſiſt of amorphous fragments of ſtones cemented together. They may be reduced to the following genera:

1. Sandſtone,
2. Puddingſtone,
3. Amygdaloid,
4. Breccia.

131 G. I. Sandſtone.

GENUS I. SANDSTONE.

Small grains of ſand, conſiſting of quartz, flint, hornſtone, ſiliceous ſhiſtus, or felſpar, and ſometimes of mica, cemented together, are denominated ſandſtones. They feel rough and ſandy; and when not very hard, eaſily crumble into ſand. The cement or baſis by which the grains of ſand are united to each other is of four kinds; namely, lime, alumina, ſilica, iron. Sandſtones, therefore, may be divided into four ſpecies.

SPECIES 1. Calcareous ſandſtones.

Calcareous ſandſtones are merely carbonat of lime or marl, with a quantity of ſand interpoſed between its particles. Though the quantity of ſand, in many caſes, far exceeds the lime, calcareous ſandſtones are ſometimes found cryſtallized: and, in ſome caſes, the cryſtals, as might be expected, have ſome of the forms which diſtinguiſh carbonat of lime. Thus the calcareous ſandſtone of Fountainbleau is cryſtallized in rhomboidal tables. It contains, according to the analyſis of Laſſone

62.5 ſiliceous ſand,
37.5 carbonat of lime.
———
100

Calcareous ſandſtones have commonly an earthy texture. Their ſurface is rough. Their hardneſs from 6 to 7. Their ſpecific gravity about 2.5 or 2.6. Their colour grey; ſometimes yellowiſh or brown. They are ſometimes burned for lime.

133 Aluminous.

SPECIES 2. Aluminous ſandſtones.

The baſis of argillaceous ſandſtones is alumina, or rather clay. Their ſtructure is often ſlaty. Their texture is compact, and either fine or coarſe grained, according to the ſize of the ſand of which they are chiefly compoſed. Their hardneſs is from 6 to 8, or even 9. Their colour is uſually grey, yellow, or brown.

They are often formed into mill-ſtones, filtering-ſtones, and coarſe whet ſtones.

134 Siliceous.

SPECIES 3. Siliceous ſandſtones.

Siliceous ſandſtones conſiſt of grains of ſand cemented together by ſilica, or ſome ſubſtance which conſiſts chiefly of ſilica or flint. They are much harder than any of the other ſpecies.

Sometimes ſtones occur, conſiſting of grains of lime cemented together with ſilica. These ſtones are alſo denominated ſiliceous ſandſtones. Aggregates

135 Ferruginous.

SPECIES 4. Ferruginous ſandſtones.

The iron which acts as a cement in ferruginous ſandſtones is not far from a metallic ſtate. When iron is completely oxydated, it loſes the property of acting as a cement. This is the reaſon that ferruginous ſandſtones, when expoſed to the air, almoſt always crumble into powder.

The colour of ferruginous ſandſtones is uſually dark red, yellow, or brown. The grains of ſand which compoſe them are often pretty large. Their hardneſs is commonly inconſiderable.

136 G. II. Pudding ſtone.

GENUS II. PUDDING STONE.

Pebbles of quartz, flint, or other ſimilar ſtones of a round or eliptical form, from the ſize of rape ſeed to that of an egg, cemented together by a ſiliceous cement, often mixed with iron, have been denominated *pudding ſtones*.

Pudding ſtones, of courſe, are not inferior in hardneſs to quartz, flint, chalcedony, &c. of which the pebbles may conſiſt. The colour of the cement is uſually yellow, brown, or red. Its fracture is conchoidal.

The finer ſorts of pudding ſtones are capable of a fine poliſh; the coarſe are uſed for mill-ſtones.

137 G. III. Amygdaloid.

GENUS III. AMYGDALOID.

Rounded or eliptical maſſes of chalcedony, zeolite, limeſtone, lithomarga, ſteatites, green earth, garnets, hornblend, or opal, cemented together by a baſis of indurated clay, trap, mullen, walken or kragg, conſtitute an *amygdaloid*.

Amygdaloids are opaque. They have no luſtre. Their fracture is uneven or conchoidal. Hardneſs 6 to 9. Their colours are as various as the ingredients of which they are compoſed.

138 G. IV. Breccia.

GENUS IV. BRECCIA.

Angular fragments of the ſame *ſpecies* of ſtone agglutinated together, conſtitute a *breccia*. Thus *calcareous* breccia conſiſts of fragments of marble cemented together by means of lime.

SECT. III. *Aggregates of Cryſtals.*

THE minerals belonging to this ſection conſiſt either of cryſtals of different kinds cemented together, or of cryſtals and amorphous ſtones cemented together.

They may be reduced under the following genera.

1. Granite.
2. Sienite.
3. Granatine.
4. Granitell.
5. Granilite.
6. Trap.
7. Porphyry.

139 G. I. Granite.

GENUS I. GRANITE.

An aggregate of felſpath, quartz, and mica, whatever be the ſize or the figure of the ingredients, is denominated *granite*. This aggregate may be divided into two ſpecies, namely, *common* granite, and *ſhiſtoſe* granite or gneiſs.

140 Common.

SPECIES 1. Common granite.

Its ſtructure is always granular. The felſpar is often amor-

Earths and Stones. amorphous, and constitutes most frequently the greatest part of the aggregate.

Common granites differ much in their appearance, according to the size, proportion, colour, and figure of their component parts They are commonly very hard: Their specific gravity varies from 2.5388 to 2.9564.

141 Gneiss. SPECIES 2. Shistose granite or gneiss.

The structure of gneiss is always slaty, and this constitutes its specific character. In gneiss, the proportion of quartz and felspar is nearly equal: the proportion of mica is smallest. It is evidently subject to the same varieties with common granite.

142 G. II. Sienite. GENUS II. Sienite.

Mr Werner has given the name of *sienite* to aggregates composed of felspar, hornblende, and quartz; or of felspar, hornblende, quartz, and mica. These aggregates were formerly confounded with quartz.

Sienite is found both of a granular and slaty structure: it might, therefore, like granite, be divided into two species. In sienite the quartz is commonly in by far the smallest proportion.

143 G. III. Granatine. GENUS III. GRANATINE.

Mr Kirwan has applied the name *granatine* to the following aggregates.

Quartz, Felspar, Shorl.	Quartz, Mica, Garnet.	Quartz, Hornblende, Jade.	Felspar, Mica, Shorl.
Quartz, Felspar, Jade.	Quartz, Shorl, Hornblende,	Quartz, Hornblende, Garnet,	Felspar, Mica, Hornblende.
Quartz, Felspar, Garnet.	Quartz, Shorl, Jade.	Quartz, Jade, Garnet.	Felspar, Quartz, Serpentine.
Quartz, Mica, Shorl.	Quartz, Shorl, Garnet.	Quartz, Hornblende, Hornstone,	Felspar, Quartz, Steatites.
Quartz, Mica, Jade.			

One of these aggregates, namely, *quartz, mica, garnet*, was called by Cronstedt *norka* or *murksten*.

144 G. IV. Granitell. GENUS IV. GRANITELL.

Mr Kirwan gives the name of *granitell* to all aggregates composed of any two of the following ingredients: quartz, felspath, mica, shorl, hornblende, jade, garnet, steatites. The most remarkable of these are:

Quartz, Felspar	Quartz, Hornblende.	Quartz, Steatites.	Felspar, Hornblende.
Quartz, Mica.	Quartz, Jade.	Felspar, Mica.	Felspar, Jade.
Quartz, Shorl.	Quartz, Garnet.	Felspar, Shorl.	Felspar, Garnet.
Mica, Shorl.	Mica, Jade.	Hornblende, Jade.	Jade, Garnet.
Mica, Hornblende.	Mica, Garnet.	Hornblende, Garnet.	Steatites, Shorl.

Some of these aggregates have received particular names. The aggregate of *quartz* and *mica*, when its structure is slaty, is called by Werner *[illegible]* by the Swedes, it is denominated *[illegible]*, whatever be its structure.

The aggregate of hornblende and mica is called *grunstein*, from the dark green colour which it usually has.

145 G. V. Granilite. GENUS V. GRANILITE.

Under the name of *granilite*, Mr Kirwan comprehends all aggregates containing more than three ingredients. Of these the following are the most remarkable.

Quartz, Felspar, Mica, Shorl.	Quartz, Mica, Shorl, Garnet.	Quartz, Sulph. of barytes, Mica, Shorl.
Quartz, Felspar, Mica, Steatites.	Quartz, Felspar, Mica, Garnet	Quartz, Sulph. of barytes, Mica, Hornblende.

146 G. VI. Trap. GENUS VI. TRAP (P).

Under this genus we class not only what has commonly been called *trap*, but also wacken, and taullen, and kragstone of Kirwan.

147 Common. SPECIES 1. Common trap.

This stone is very common in Scotland, and is known by the name of *whinstone*. Whole hills are formed of it; and it occurs very frequently in large rounded detached fragments. Sometimes it assumes the form of immense columns, and is then called *basalt*. The Giant's Causeway in Ireland, the island of Staffa, and the south side of Arthur's Seat in Scotland, are well known instances of this figure

Its texture is earthy or compact. Its fracture uneven. Its lustre commonly 0. Opaque. Hardness 8 to 9. Not brittle. Sp. gr from 2.[illegible] to 3.021 *. Colour black, with a shade of grey, blue, or purple; sometimes blackish or reddish brown: in some cases greenish grey. By exposure to the atmosphere, it often becomes invested with a brownish rind. Before the blow-pipe, it melts *per se* into a more or less black glass.

* Kirwan.

Trap consists of small crystals of hornblende, felspar, olivine, &c. usually set in a ground composed apparently of clay and oxyd of iron. A specimen, in the form of basaltes, from Staffa, analysed by Dr Kennedy of Edinburgh, contained 48 silica,

16 alumina,
16 oxyd of iron,
9 lime,
5 moisture,
4 soda,
1 muriatic acid.

99 †

(P) *Kirw.* I. 231 and 431.—*Faujas de St Fond. Essai sur l'Hyl. Nat des Roch.* [illegible] *Phil. Trans.* passim. See also a very ingenious set of experiments on the fusion of trap, by Sir James Hall in [illegible] V. 43.

Earths and ... A specimen from Salisbury rock, near Edinburgh, contained, according to the analysis of the same gentleman,

46.0	silica,
19.0	alumina,
17.0	oxyd of iron,
8.0	lime,
4.0	moisture,
3.5	soda,
1.0	muriatic acid.
98.5 ‡	

‡ E. Tra. 90. Dr Kennedy conducted these analyses with great ingenuity and judgment; and the discovery in which they terminated, that trap contains soda, is certainly of importance, and may lead to valuable consequences both in a geological and mineralogical view.

148 Wacken. SPECIES 2. Wacken *.

* Kirw. i. 223. This stone often forms considerable parts of hills, and, like trap, is amorphous. Its texture is earthy. Its fracture usually even. Lustre 0. Opaque. Hardness 6 to 9. Sp. gr. from 2.535 to 2.893 †. Colour grey, with a shade of green, black, red, brown. When exposed to the atmosphere, it withers and becomes more grey.

† Kirwan.

It melts into a grey porous slag.

149 Mullen. SPECIES 3. Mullen ‡.

‡ Kirw. i. 225. This stone is also found in considerable masses, and sometimes has a tendency to a columnar form like basalt. Texture earthy. Fracture uneven, and fine splintery. Lustre 0, except from some shining particles of basaltine. Opaque. Hardness from 7 to 9. Sp. gr. from 2.6 to 2.738. Colour ash or bluish grey; sometimes mixed with ochre yellow, in consequence of the decomposition of the stone. At 130° Wedgewood it melts into a black compact glass.

When mullen is exposed to the air, its surface becomes covered with a greyish white rind, sometimes slightly ochry.

150 Kragstone. SPECIES 4. Kragstone *.

* Kirw. i. 226. This stone, which, like the others, forms considerable parts of rocks, was formed into a distinct species by Mr Kirwan. Its texture is earthy. It is exceedingly porous, and the pores are often filled with the crystals of other minerals. Fracture uneven. Lustre 0. Opaque. Hardness 5 to 7. Sp. gr. 2.314. Feels rough and harsh. Colour reddish grey. Streak yellowish grey. At 138° Wedgewood it melts into a reddish brown porcelain mass.

151 G. VII. Porphyry. GENUS VII. PORPHYRY.

Any stone which contains scattered crystals or grains of felspar, visible to the naked eye, is denominated a *porphyry*. Besides felspar, porphyries generally contain small crystals of quartz, hornblende, and mica. These crystals are usually of a different colour from the stone in which they are found, and they are stuck in it as in a cement. It is evident from this definition, that the number of porphyries must be great. Each species receives its name from the stone which forms its basis. To describe them would be unnecessary. We shall only give a catalogue of the principal species.

Aggregates.

1. Hornstone porphyry.
2. Pitchstone porphyry.
3. Hornslate porphyry.
4. Felspar or petunse porphyry.
5. Clay porphyry.
6. Hornblende porphyry.
7. Trap porphyry.
8. Wacken porphyry.
9. Mullen porphyry.
10. Krag porphyry.
11. Argillitic porphyry.
12. Potstone porphyry.
13. Serpentine porphyry.
14. Sandstone porphyry.

The aggregates belonging to this section compose most of the mountains of the globe. In giving an account of them, we have adhered implicitly to the arrangement most generally received by mineralogists. It must be acknowledged, that this arrangement is by no means complete, and that some of the genera are too vague to be of much use. The number of aggregates already discovered is too great for giving to each a particular name. Perhaps it would be better henceforth to adopt the method proposed by Mr Hauy, namely, to constitute the genera from that ingredient which enters most abundantly into the aggregate, and which forms as it were its basis, and to distinguish the species according to the nature and proportion of the other ingredients. According to this plan, the aggregates hitherto discovered have been divided by Hauy into the following genera:

1. Felspathic rock.
2. Quartzous rock.
3. Micaceous rock.
4. Chloritous rock.
5. Serpentine rock.
6. Trappean rock.
7. Hornblendean rock.
8. Petro-siliceous rock.
9. Garnetic rock.
10. Calcareous rock.
11. Argillaceous rock.
12. Corneous rock.

SECT. IV. *Volcanic Aggregates.*

AGGREGATES formed by volcanoes may be reduced to the following genera.

1. Lava.
2. Tufa.
3. Pumice.
4. Ashes.

GENUS I. LAVA. 152 G. I. Lava.

All substances which have issued out of a volcano in a state of fusion are called *lavas*. They have been divided into three species.

SPECIES 1. Vitreous lava. 153 Vitreous.

Found in small pieces.

Texture glossy. Fracture conchoidal. Lustre 3. Transparency from 3 to 1. Hardness 9 to 10. Sp. gr. from 2 to 3. Colour blackish, greenish, or whitish. Commonly somewhat porous.

SPECIES 2. Cellular lava. 154 Cellular.

This species is full of cells. Surface rough and full of cavities. Texture earthy. Lustre 0. Opaque. Hardness 7 to 9. Sp. gr. varies, but does not exceed 2.8. Colour brown or greyish black. Commonly somewhat magnetic.

SPECIES 3. Compact lava. 155 Compact.

This species is the most common of all; it runs into the

the ſecond by inſenſible degrees; and indeed is ſeldom found of any conſiderable ſize without ſome pores. It bears in general a very ſtrong reſemblance to trap.

A ſpecimen of the lava of Catania in Sicily, analyſed by Dr Kennedy, contained

51.0	ſilica,
19.0	alumina,
14.5	oxyd of iron,
9.5	lime,
4.0	ſoda,
1.0	muriatic acid.
99.0 †	

A ſpecimen of the lava of Sta. Venere in Sicily he found to contain

50.75	ſilica,
17.50	alumina,
14.25	oxyd of iron,
10.00	lime,
4.00	ſoda,
1.00	muriatic acid.
97.5 ‡.	

Thus we ſee, that the reſemblance between trap and lava holds not only in their external appearance, but alſo in their component parts.

† Tranſ. Edin. v. 93.

156 G. II. Puzzolana.

Genus II. puzzolana.

Found in ſmall pieces. Surface rough. Texture earthy and porous. Fracture uneven. Luſtre 0. Opaque. Hardneſs 3. Very brittle. Sp. gr. from 2.57 to 2.8. Colour brown or dark grey. Magnetic. Eaſily melts into a black ſlag.

When mixed with lime into a mortar, it poſſeſſes the property of hardening even under water. This property it owes moſt probably, as Mr Kirwan ſuppoſes, to the iron which it contains. The iron decompoſes the water of the mortar, and by this means it becomes too hard to be acted upon by water in a very ſhort time.

157 G. III. Pumice.

Genus III. pumice.

This is a very light ſubſtance ejected from volcanoes. It is porous. Hardneſs 3. Brittle. Sp. gr. below 1. Colour grey or brown.

In ſome varieties the luſtre and tranſparency are 0: in others, the luſtre is glaſſy, 2. Tranſparency from 1 to 2.

158 G. IV. Volcanic aſhes.

Genus IV. volcanic ashes.

Theſe are analogous to the aſhes of common pit coal. Looſe and ſmooth, very light, and fine. Slowly diffuſible in water, and when wet ſomewhat ductile.

Class II. SALTS.

UNDER this claſs we comprehend all the combinations of alkalies with acids which exiſt in the mineral kingdom. As they have been already deſcribed in the article Chemistry, *Suppl.* we ſhall here only give a liſt of their names.

159 Genera.

Genus I. potass.

Sp. 1. Sulphat of potaſs.
2. Nitrat of potaſs.

Genus II. soda.

Sp. 1. Carbonat of ſoda.
2. Sulphat of ſoda.
3. Muriat of ſoda.
4. Borax.

Genus III. ammonia.

Sp. 1. Sulphat of ammonia.
2. Muriat of ammonia.

Class III. COMBUSTIBLES.

160 Genera.

THE combuſtible ſubſtances belonging to the mineral kingdom, excluding the metals, may be comprehended under the following genera.

1. Sulphur.
2. Carbon.
3. Bitumen.
4. Coal.
5. Amber.

Genus I. sulphur.

species 1. Native ſulphur.

This ſubſtance is found abundantly in many parts of the world, eſpecially near volcanoes, as Hecla, Ætna, Veſuvius, the Lipari iſlands, &c. It is either in the ſtate of powder, or maſſive, or cryſtallized. The primitive form of its cryſtals is an octohedron, compoſed of two four-ſided pyramids, joined baſe to baſe †. The ſides of theſe pyramids are ſcalene triangles, and ſo inclined that the plane where the baſes of the pyramids join is a rhomb, whoſe long diagonal is to its ſhort as 5 to 4 *. Sometimes the apices of the pyramids, to uſe the language of De Liſle, are truncated; ſometimes they are ſeparated from each other by a priſm; ſometimes they are truncated near their baſes, and a low four-ſided pyramid riſes from the truncature: this pyramid is alſo ſometimes truncated near its apex ‡. Finally, one of the edges of the pyramids is ſometimes truncated. For figures of theſe varieties, and for the laws of their formation, we refer to *Mr Lefroy* †.

Colour yellow, with a ſhade of green; ſometimes reddiſh (q). Luſtre greaſy, 2. Tranſparency varies from 0 to 4. Cauſes double refraction ‡. Texture compact. Hardneſs 4 to 5. Brittle.—For its other properties, we refer to Chemistry in this *Suppl.*

Sometimes ſulphur is mixed with different proportions of earths. Theſe combinations are hardly ſuſceptible of accurate deſcription.

Sulphur combines alſo with metals. Theſe combinations ſhall be deſcribed in the fourth claſs.

† Fig. 34.

* Romé de Liſle, i. 292. Haüy and Lefroy, Jour. de Min. N° xxix. 337.

‡ Fig.

† Jour. de Min. N° xxix. 337.

‡ Haüy.

161 G. II. Carbon.

Genus II. carbon.

This genus comprehends all minerals compoſed of pure carbon, or of carbon combined with a little earth.

162 Diamond.

species 1. Diamond.

This mineral, which was well known to the ancients,

(q) It then contains arſenic.

[illegible] parts of Asia, particularly in the kingdoms of Golconda and Visapour, it is found also in Brazil.

It is always crystallized; but sometimes so imperfectly, that at the first sight it might pass for amorphous. Its primitive form is a regular octogon; but it more commonly assumes a spheroidal form, and then has nearly 30 curvilinear triangular faces, 6 of which are raised upon each of the faces of the primitive octogon †. Its integrant molecule, according to Hauy, is a regular tetrahedron. — For a more particular account of the crystals of this mineral, we refer the reader to *Mr Romé de Lisle* and *Mr Hauy* †.

Texture foliated. Lustre 4. Transparency from 2 to 4. Causes single refraction. Hardness 20. Sp. gr. 3.5185 to 3.5310 †. Colour various; sometimes limpid, sometimes red, orange, yellow, green, blue, and even blackish.

When rubbed it becomes positively electric, even before it has been cut by the lapidary, which is not the case with any other gem §.

It is composed of pure carbon §.

164 Mineral charcoal.

SPECIES 2. Mineral charcoal.

Kilkenny coal—Wales culm.

This mineral has been found in Hungary, Italy, France, Ireland, and Wales. It occurs in stratified masses, or in lumps nested in clay.

Colour black. Lustre 4, metallic. Opaque. Texture foliated. Hardness 5 to 7. Sp. gr. 1.4 to 1.526. Often stains the fingers. Insoluble in acids. Deflagrates with nitre. Does not burn till wholly ignited, and then consumes slowly without emitting flame or smoke.

It consists almost entirely of *charcoal*, which, as Morveau has proved, is an oxyd of carbon *.

SPECIES 3. Anthracite (R).

Anthracolite.

This substance, as Dolomieu informs us, is found exclusively in the primitive mountains. It is always amorphous. Colour black or brownish black. Lustre 3 to [illegible]. Structure slaty. Fragments rhomboidal. Hardness 6 to 7. Sp. gr. greater than that of coal. Often stains the fingers.

Burns precisely like the last species, and leaves .40 of white ashes. According to Dolomieu, it is composed of [illegible]

64.0 charcoal,
32.5 silica,
3.5 iron,
—
100.0 †

It is probable that the charcoal in the two last substances is in the same state in which it exists in plumbago, combined with oxygen, but not containing so much as charcoal does ‡.

165 G. III. Bitumen.

GENUS III. BITUMEN.

By bitumen we understand, with mineralogists in general, an oil, which is found in different parts of the earth, in various states of consistence. These different states form distinct species; in our arrangement of which we shall be guided by the observations which Mr Hatchett has made in his valuable paper on bituminous substances *.

Combustibles.

SPECIES 1. Naphtha. 167 Naphtha.

This substance is found sometimes on the surface of the water of springs, and sometimes issuing from certain strata. It is found in great abundance in Persia.

It is as fluid and transparent as water. Colour white or yellowish white. Smell strong, but not disagreeable. Sp. gr. when white, .708 * or .729 †; when yellowish, .8475 ‡. Feels greasy. Catches fire on the approach of flame, burns with a white flame, and leaves scarce any residuum.

Insoluble in alcohol. Does not freeze at 0° Fahrenheit. When pure naphtha is exposed to the air, it becomes yellow and then brown; its consistence is increased, and it passes into *petroleum* *.

SPECIES 2. Petroleum. 168 Petroleum.

This substance is also found in Persia, and likewise in many countries in Europe, particularly Italy, France, Switzerland, Germany, Sweden, England, and Scotland.

Not so fluid nor transparent as water. Colour yellow, either pale or with a shade of red or green; reddish brown and reddish black. Smell that of naphtha, but less pleasant. Sp. gr. .8783 *. When burned it yields a soot, and leaves a small quantity of coally residuum.

By exposure to the air it becomes like tar, and is then called *mineral tar* †.

SPECIES 3. Mineral tar. 169 Mineral tar.

This substance is found in many parts of Asia, America, and Europe. It is viscid, and of a black, brownish black, or reddish colour. Smell sometimes strong, but often faint. Sp. gr. 1.1. When burned, emits a disagreeable bituminous smell. By exposure to the air it passes into *mineral pitch* and *maltha* *.

SPECIES 4. Mineral pitch and maltha. 170 Mineral pitch and maltha.

This substance has a strong resemblance to common pitch. When the weather is warm it is soft, and has some tenacity; it is then called *adhesive mineral pitch*: when the weather is cold, it is brittle; its hardness is 5; and its fracture has a glassy lustre. In this state it is called *maltha*. Colour black, dark brown, or reddish. Lustre 2. Opaque. Sp. gr. from 1.45 to 2.07. Does not stain the fingers. On a white hot iron it flames with a strong smell, and leaves a quantity of grey ashes. It is to the presence of the earths which compose these ashes that the great specific gravity of this bitumen is to be ascribed. By farther induration, it passes into *asphalt*.

SPECIES 5. Asphalt. 171 Asphalt.

This substance is found abundantly in many parts of Europe, Asia, and America, especially in the island of Trinidad.

Colour black or brownish black. Lustre greasy 2. Opaque. Fracture conchoidal, of a glassy lustre. Hardness from 7 to 8. Very brittle. Sp. gr. 1.07 to 1.165 *. Feel smooth, but not greasy. Does not stain the fingers. Has little or no smell, unless when rubbed or heated. When heated melts, swells, and inflames; and when pure, burns without leaving any ashes.

SPECIES 6. Elastic bitumen. 172 Elastic bitumen.

Mineral caoutchouc.

This substance was found about the year 1786 in the lead

(R) This name was given by Hauy from [illegible] *coal*.

† Romé de Lisle. ‡ Hauy. § Morveau, Ann. de Chim. xxvi. * Morveau, ibid. ‡ Morveau, ibid. * Nich. Jour. [illegible]

* Muschenbroek. † Bouldoc. ‡ Brisson. * Hatchett. * Brisson. † Hatchett, ibid. * Hatchett, ibid. * Kirwan.

Combus- lead mine of Odin, near Castletown, Derbyshire. It was first mentioned by Mr De Born.

Colour yellowish or reddish brown, sometimes blackish brown. In its appearance it has a strong resemblance to caoutchouc or Indian rubber; hence its name. Consistency various: sometimes so soft as to adhere to the fingers; sometimes nearly as hard as asphalt. When soft it is elastic; when hard brittle. Sp. gr. 0.9053 to

‡ Hatchett, ibid. 1.0233‡.

Insoluble in alcohol, ether, and oil of turpentine, but soluble in oil of olives. Not affected by nitric acid. When distilled, it yields a bituminous oil insoluble in

* Lametherie, Jour. de Phys. xxxi. 312. alcohol; the residuum is carbonaceous*.

There is a variety of this substance found in a rivulet near the mine of Odin, which, when fresh cut, exactly resembles fine cork in colour and texture; but in a few days after being exposed to the air, becomes of a pale reddish brown. This substance contains within

† Hatchett, ibid. it a nucleus of elastic bitumen. It seems to be the elastic bitumen altered in its texture by the water †.

173 G. IV Coal.

Genus IV. coal.

The substances belonging to this genus are composed of carbon or rather charcoal, and bitumen.

174 Jet.

species 1. Jet (s).

This substance is found in France, Spain, Germany, Britain, and other countries. It is found in detached kidneyform masses, of various sizes, from an inch to seven or eight feet in length.

Colour full black. Lustre 3 to 4; internal glassy. Opaque. Hardness 7 to 8. Not near so brittle as asphalt. Texture striated. Fracture conchoidal. Sp.

* Brisson. gr. 1.259*. It has no odour except when heated, and then it resembles the odour of asphaltum. Melts in a strong heat, burns with a greenish flame, and leaves an

† Hatchett. earthy residuum†.

‡ Kirwan. Becomes somewhat electric by friction ‡. When

§ Vauquelin. distilled yields a peculiar acid §.

This mineral is formed into buttons, beads, and other

‖ Jour. de Min. N° iv. 41. trinkets. The manufacture has been almost confined to France ‖.

175 Cannel coal.

species 2. Cannel coal.

This mineral is found in Lancashire, and in different parts of Scotland, where it is known by the name of *parrot coal*.

Colour black. Lustre common, 2. Opaque. Structure sometimes slaty. Texture compact. Fracture conchoidal. Hardness 5 to 8. Brittle. Sp. gr. 1.232 to 1.426. Does not stain the fingers.

Kindles easily, and burns with a bright white flame like a candle (T), which lasts but a short time. It does not cake. It leaves a stony or sooty residuum.

A specimen of Lancashire cannel coal, analysed by Mr Kirwan, contained

75.20 charcoal,
21.68 maltha,
3.10 alumina and silica.

99.98†

† Mineral. ii. 523.

A specimen of the slaty kind from Ayrshire, called *splent coal*, was composed of — Combustibles.

47.62 charcoal,
32.52 maltha,
20.00 earths.

100.14‡

‡ Ibid. 524.

Cannel coal is susceptible of polish, and, like jet, is often wrought into trinkets.

176 Common coal.

species 3. Common coal.

This very useful combustible is never found in the primitive mountains, but only in the secondary mountains, or in plains formed of the same materials with them. It is always in strata, and generally alternates with clay, sandstone, or limestone.

Colour black, more or less perfect. Lustre usually greasy or metallic, 2 to 4. Opaque. Structure generally slaty. Texture often foliated. Fracture various. Hardness 4 to 6. Sp. gr. 1.25 to 1.37. Usually stains the fingers. Takes fire more slowly, and burns longer, than the last species. Cakes more or less during combustion.

Of this species there are many varieties, distinguished in Britain by the names of caking coal, rock coal, &c. These are too well known to require any description.

Mr Kirwan analysed a variety of different kinds of coal: The result of his experiments may be seen by the following table.

Whitehaven coal.	Wigan	Swansey	Leitrim	
57.0	61.73	73.53	71.43	charcoal.
41.3	36.7	23.14	23.37	maltha & asph
1.7	1.57	3.33	5.20	earths ‡.
100.0	100.00	100.00	100.00	

‡ Mineral. ii. 525.

177 Spurious coal.

species 4. Spurious coal.

This mineral is generally found amidst strata of genuine coal. It is also called *parrot coal* in Scotland.

Colour greyish black. Lustre 0 to 1. Structure usually slaty. Texture earthy. Hardness 7 to 8. Sp. gr. 1.5 to 1.6. Generally explodes, and bursts when heated.

Composed of charcoal, maltha, and asphalt, and above .20 of stony matter.

178 G. V. Amber.

Genus V. amber.

species 1. Common amber.

This substance, called *electrum* by the ancients, is found in different countries; but most abundantly in Prussia, either on the sea shore, or under ground at the depth of about 100 feet, reposing on *wood coal**. It

* Kirw. Min. ii. 66. is in lumps of different sizes.

Colour yellow. Lustre 3 to 2. Transparency 2 to 4. Fracture conchoidal. Hardness 5 to 6. Sp. gr. 1.078 to 1.085. Becomes electric by friction.

If a piece of amber be fixed upon the point of a knife, and then kindled, it burns to the end without melting †.

By distillation it yields succinic acid.

(s) It was called *gagathes* by the ancients, from the river Gages in Licia, [illegible] which it was found [illegible] French, *azabache* in Spanish, *gagath* in German.

(T) Hence it has been called *cannel coal*. *Candle*, in the Lancashire and Scotch dialect, [illegible] *cannel*.

Class IV. METALLIC ORES.

This class comprehends all the mineral bodies, composed either entirely of metals, or of which metals constitute the most considerable and important part. It is from the minerals belonging to this class that all metals are extracted; for this reason they have obtained the name of *ores*.

179 Orders. The metals hitherto discovered amount to 21; we shall therefore divide this class into 21 orders, allotting a distinct order for the ores of every particular metal.

Metals exist in ores in one or other of the four following states. 1. In a metallic state, and either solitary or combined with each other. 2. Combined with sulphur. 3. In the state of oxyds. 4. Combined with acids. Each order therefore may be divided into the four following genera.

180 Genera

1. Alloys.
2. Sulphurets.
3. Oxyds.
4. Salts.

It must be observed, however, that every metal has not hitherto been found in all these four states, and that some of them are hardly susceptible of them all. Some of the orders therefore want one or more genera, as may be seen from the following table.

Order I. *Gold ores.*
 1. Alloys.
Order II. *Silver ores.*
 1. Alloys.
 2. Sulphurets.
 3. Oxyds.
 4. Salts.
Order III. *Platinum ores.*
 1. Alloys.
Order IV. *Ores of mercury.*
 1. Alloys.
 2. Sulphurets.
 3. Oxyds.
 4. Salts.
Order V. *Copper ores.*
 1. Alloys.
 2. Sulphurets.
 3. Oxyds.
 4. Salts.
Order VI. *Iron ores.*
 1. Alloys.
 2. Sulphurets.
 3. Carburets.
 4. Silicated iron.
 5. Oxyds.
 6. Salts.
Order VII. *Tin ores.*
 1. Sulphurets.
 2. Oxyds.
Order VIII. *Lead ores.*
 1. Sulphurets.
 2. Oxyds.
 3. Salts.
Order IX. *Zinc ores.*
 1. Sulphurets.
 2. Oxyds.
 3. Salts.
Order X. *Antimonial ores.*
 1. Alloys.
 2. Sulphurets.
 3. Oxyds.
 4. Salts.
Order XI. *Bismuth ores.*
 1. Alloys.
 2. Sulphurets.
 3. Oxyds.
Order XII. *Arsenic ores.*
 1. Alloys.
 2. Sulphurets.
 3. Oxyds.
Order XIII. *Cobalt ores.*
 1. Alloys.
 2. Sulphurets.
 3. Oxyds.
 4. Salts.
Order XIV. *Nickel ores.*
 1. Sulphurets.
 2. Oxyds.
 3. Salts.
Order XV. *Manganese ores.*
 1. Oxyds.
 2. Salts.
Order XVI. *Tungsten ores.*
 1. Oxyds.
 2. Salts.
Order XVII. *Ores of molybdenum.*
 1. Sulphurets.
Order XVIII. *Ores of uranium.*
 1. Oxyds.
 2. Salts.
Order XIX. *Ores of titanium.*
 1. Oxyds.
Order XX. *Ores of tellurium.*
 1. Alloys.
Order XXI. *Ores of chromum.*
 1. Oxyds.

Order I. GOLD ORES.

No metal perhaps, if we except iron, is more widely scattered through the mineral kingdom than gold *. Hitherto it has been found only in a metallic state; most commonly in grains, ramifications, leaves, or rhomboidal, octohedral, or pyramidal crystals. It is generally mixed with quartz, though there are instances of its having occurred in calcareous rocks. It is not uncommon also to find it disseminated through the ores of other metals; especially iron, mercury, copper, and zinc. The greatest quantity of gold is found in the warmer regions of the earth. It abounds in the sands of many African rivers, and is very common in South America and India. Europe, however, is not destitute of this metal. Spain was famous in ancient times for its gold mines, and several of the rivers in France contain it in their sands †. But the principal gold mines in Europe are those of Hungary, and next to them those of Salzburg. Gold also has been discovered in Sweden and Norway, and more lately in the county of Wicklow in Ireland ‡. 181 Where found.

* Bergman.

† Reaumur, Mem. Par. 1718, p. 68.

‡ Lloyd, Phil. Trans. 1790, p. 36. Mills, ibid. p. 38.—Nicholson's Journ. ii. 224.

Genus I. Alloys of gold.

Species 1. Native gold.

182 G. I. Native gold.

Native gold is never completely pure; it is alloyed with some silver or copper, and sometimes with iron. In the native gold found in Ireland, indeed, the quantity of alloy appears to have been exceedingly small.

Its colour is yellow. Lustre metallic. Fracture hackly. Hardness 5. Sp. gr. from 12 to 19.

Order II. SILVER ORES.

Silver is found most commonly in quartz, limestone, hornstone; or combined with the ores of other metals, most commonly with copper, antimony, zinc, cobalt, and lead. This last metal indeed is seldom totally destitute of silver. 183 Where found.

Genus I. Alloys of silver.

Species 1. Native silver *.

184 G. I. Native silver.

Native silver, so called because the silver is nearly in a state of purity, forms the principal part of some of the richest silver mines in the world. It is sometimes in small lumps; sometimes crystallized in cubes, hexahedrons, octohedrons, or dodecahedrons; sometimes in leaves, or threads, often so connected with each other as to resemble branches of trees, and therefore called *dendrites*. The silver in the famous mines of Potosi has this last form. When newly extracted, it is not unlike small branches of fir †.

The colour of native silver is white; often tarnished. Lustre metallic. Fracture hackly. Hardness 6. Malleable. Sp. gr. from 10 to 10.338.

The silver in this species is almost constantly alloyed with from .03 to .05 of some other metal, frequently gold or arsenic.

* Kirw. ii. 108.—Collings. Act. Liter. Svecia, 1738, p. 440.

† Bergman's Phys. Geogr. Jour. de Min. No xvi. p. 26.

Silver

185 Alloy of silver and gold.

SPECIES 2. Alloy of silver and gold.

Auriferous native silver.

This alloy is not uncommon in silver mines. Its colour is yellowish white. Its lustre metallic. Hardness 5. Malleable. Sp. gr. above 10.6. Dr Fordyce found a specimen from Norway composed of

72 silver,
28 gold.

100*

* *Phil. Trans.* 1776, p 532.

SPECIES 3. Alloy of silver and antimony †.

Antimoniated silver ore.

186 Alloy of silver and antimony. This alloy, which is found in the silver mines of Spain and Germany, is sometimes in grains or lumps, and sometimes crystallized in six-sided prisms, whose sides are longitudinally channelled ‡.

Its colour is white. Its lustre metallic. Hardness 10. Brittle. Sp. gr. from 9.4406 § to 10||. Texture foliated. Fracture conchoidal. Before the blow-pipe the antimony evaporates in a grey smoke, and leaves a brownish slag, which tinges borax green. If borax be used at first, a silver bead may be obtained.

This alloy was long supposed to contain arsenic. Bergman examined it, and found only silver and antimony ¶. His analysis has been confirmed by the experiments of Vauquelin and Selb *. According to Selb, it is composed of 89 silver,

11 antimony.

100

A specimen, analysed by Klaproth, contained

84 silver,
16 antimony.

100

Another specimen contained

76 silver,
24 antimony.

100 †

† Kirwan, ii. 110.
‡ Romé de Lisle, iii. 401.
§ Haüy, Jour. de Min. N° xxx p 473.
|| Kirwan, ibid.
¶ Opusc. ii 415.
* Jour. de Min. ibid
† Beiträge, ii. 301.

GENUS II. SULPHURETS OF SILVER.

187 G. II. Sulphurets. Common sulphuret of silver.

SPECIES 1. Common sulphuret of silver ‡.

Vitreous silver ore.

This ore occurs in the silver mines of Germany and Hungary. It is sometimes in masses, sometimes in threads, and sometimes crystallized. Its crystals are either cubes or regular octohedrons, whose angles and edges are often variously truncated. For a description of the varieties produced by these truncatures, we refer the reader to *Romé de Lisle* ¶.

Its colour is dark bluish grey, inclining to black; often tarnished. Internal lustre metallic. Texture foliated. Fracture uneven. Hardness 4 to 5. May be cut with a knife like lead. Flexible and malleable. Sp. gr. 6 909* to 7.215 †. In a gentle heat the sulphur evaporates. Melts when heated to redness.

A specimen of this ore, analysed by Klaproth, contained

85 silver,
15 sulphur.

100 ‡

‡ Kirwan, ii. 115.
¶ Crystal. 441.
* Brisson.
† Gellert.
‡ Beiträge, i. 162.

SPECIES 2. Antimoniated silver ore *.

Sulphuret of silver with antimony and iron.

188 Antimoniated silver ore. This ore, which occurs in Saxony and Hungary, seems to be sulphuret of silver contaminated with antimony and iron, and ought therefore, in all probability, to be considered merely as a variety of the last species. It is sometimes in masses, but more frequently crystallized in six-sided prisms, tables, or rhomboids; generally indistinct and accumulated together.

Its colour is iron grey; often tarnished. Its lustre metallic. Fracture uneven. Hardness 4 to 5. Brittle. Sp. gr. 7.208 †. Before the blow pipe the sulphur and antimony exhale, leaving a bead, which may be freed from iron by fusion with nitre and borax.

A specimen of this ore, analysed by Klaproth, contained

66.5 silver,
12.0 sulphur,
10.0 antimony,
5.0 iron,
1.0 silica,
0.5 arsenic and copper.

95.0 ‡

* Kirwan, ii. 118.
† Gellert.
‡ Beiträge, i. 160.

SPECIES 3. Sulphuret of silver and copper *.

Cupriferous sulphurated silver ore.

189 Sulphuret of silver and copper. This ore, which is found in the Korbolokinsk mountains in Siberia, was first described by Mr Renovantz. It is in amorphous masses, varying in size from that of the thumb to that of the fist.

Its colour is bluish grey like lead. Lustre metallic. Hardness 5 to 6. Brittle. Its powder, when rubbed on the skin, gives it a black colour and a leaden gloss. Before the blow-pipe the sulphuret of silver melts readily; that of copper with difficulty. This ore is composed of about

42 silver,
21 copper,
35 sulphur.

98

* Kirwan, ii. 121.

GENUS III. OXYDS OF SILVER.

190 G. III. Oxyds. Calciform silver ore.

SPECIES 1. Calciform silver ore †.

This ore was first described by Mr Widenman. It is sometimes in masses, sometimes disseminated through other minerals.

Its colour is greyish black. Its streak bright. Its lustre metallic. Its fracture uneven. Hardness 4 to 5. Brittle. Sp. gr. considerable. Effervesces with acids. Melts easily before the blow-pipe. Froths with borax.

According to Selb, it contains 72.5 silver,

15.5 copper,
12.0 carbonic acid.

100.0

† Kirwan, ii. 112.

SPECIES 2. Red silver ore (v).

191 Red silver ore. This ore is very common in several German silver mines. It occurs in masses, disseminated and crystallized. The primitive form of its crystals is a dodecahedron ‡, whose sides are equal rhombs, and which may be con-

‡ Fig. 38.

(v) *Kirw.* II. 122.—*Scopoli de Minera Argenti Rubra.*—*Sage*, *Jour. de Phys.* XXXIV. 331. and XLI. 370; and *Nouv. Jour. de Phys.* II. 284.—*Westrum*, *Jour. de Phys.* XLIII. 291.—*Klaproth*, *Beiträge*, I. 141.

Silver. considered as a six sided rhomboidal prism, terminated by three sided summits *. Sometimes the prism is lengthened, and sometimes its edges, or those of the terminating summits, or both, are wanting. For a description and figure of these varieties, we refer to *De Lisle* † and *Hauy* ‡.

Its colour is commonly red. Streak red. External lustre metallic, internal common. Transparency from 3 to 1; sometimes opaque. Fracture flat conchoidal. Hardness 5 to 7. Brittle. Sp. gr. from 5.44 § to 5.592 ¶. Becomes electric by friction, but only when insulated ‖. Soluble in nitric acid without effervescence *. Before the blow pipe melts, blackens, burns with a blue flame, gives out a white smoke with a slight garlic smell, and leaves a silver bead †.

Variety 1. Light red.

Colour intermediate between blood and cochineal red; sometimes variegated. Streak orange red. Powder black.

Variety 2. Dark red.

Colour commonly between dark cochineal red and lead grey; sometimes nearly black and without any shade of red. Streak dark crimson red.

This ore was long supposed to contain arsenic. Klaproth first ascertained its real composition ‡; and his analysis has been confirmed by Vauquelin, who found a specimen composed of 56.6748 silver,

16.1300 antimony,
15.0666 sulphur,
12.1286 oxygen.

100.

Klaproth proved, that the silver and antimony are in the state of oxyds; and Vauquelin, that the sulphur is combined partly with the oxyd of silver and partly with the oxyd of antimony. Klaproth obtained a little sulphuric acid; but this acid, as Vauquelin, with his usual ingenuity, demonstrated, was formed during the analysis.

This ore sometimes contains a minute portion of arsenic, but never more than .02 *.

* Rome de Lisle, iii. 447.
† Ibid.
‡ Jour. d'Hist. Nat. N° 18. p. 21.
§ Kirwan.
¶ Vauquelin, Jour. de Min. N° xvii. p. 2.
‖ Hauy, ibid. N° xxx. p. 470.
* Hauy, ibid. N° xxxi. p. 515.
† Vauquelin, ibid.
‡ Ann. de Chim. xvii.
* Vauquelin, ibid. p. 3.

GENUS IV. SALTS OF SILVER.

SPECIES 1. Muriat of silver (x).

Corneous silver ore.

192 G. IV. Salts. Muriat of silver. This ore occurs at Johanngeorgenstadt in Saxony, in South America, &c. It is often amorphous, sometimes nearly in powder, and sometimes crystallized in cubes or parallelopipeds.

Its colours are various: when exposed to the light it becomes brown. Internal lustre greasy, 2; external, 2 to 1. Acquires a gloss when scraped with a knife. Transparency 2 to 1. Texture foliated. Hardness 4 to 5. Sp. gr. 4.745 * to 4.804 †. Before the blow-pipe it instantly melts, and gradually evaporates, but may be reduced by adding an alkali.

* Prisson.
† Gellert.

Metallic ores

That this ore contains muriatic acid, has been long known. Mr Woulfe first shewed that it contained also sulphuric acid ‡: and this discovery has been confirmed by Klaproth, according to whose analysis this ore is composed of

67.75 oxyd of silver,
6.00 oxyd of iron,
21.00 muriatic acid,
.25 sulphuric acid,
1.75 alumina.

96.75 ¶

The alumina can only be considered as mixed with the ore. Sometimes its quantity amounts to .67 of the whole §.

‡ Phil. Trans. 1776.
¶ Beiträge, i. 134.
§ Ibid. p. 137.

ORDER III. ORES OF PLATINUM (y).

193 Mines. HITHERTO no mine of platinum has been discovered. It is found in small scales or grains on the sands of the river Pinto, and near Carthagena in South America. It is always in a metallic state, and always combined with iron.

GENUS I. ALLOYS OF PLATINUM.

SPECIES 1. Native platinum.

194 G. I. Alloys. Native platinum. Its colour is whitish iron grey. Magnetic. Sp. gr. from 12 to 16. Soluble in nitro-muriatic and oxy-muriatic acids.

ORDER IV. ORES OF MERCURY.

MERCURY is employed in medicine; it serves to separate silver and gold from their ores; the silvering of looking glasses, gilding, &c. are performed by means of it; and its sulphuret forms a beautiful paint.

195 Mines. Mercury abounds in Europe, particularly in Spain, Germany, and Hungary: it is found also in China (z), the Philippines *, and in Peru, and perhaps Chili (A) in South America. The most productive mines of mercury are those of Idria †; of Almaden, near Cordova in Spain, which were wrought by the Romans (B); of the Palatinate ‡; and of Guanca Veliça in Peru (C).

Mercury has never been found in Britain, nor has any mine worth working been discovered in France. It occurs most commonly in argillaceous shistus, limestones, and sandstones.

* Carreri Voyage.
† Scopoli, Jour. de Min. N° xxxvi. p. 915.
‡ Jour. de Min. Nos vi. and vii.

GENUS I. ALLOYS OF MERCURY.

SPECIES 1. Native mercury.

196 G. I. Alloys. Native mercury. Native mercury is found in most mercurial mines: it is in small globules, scattered through different kinds of stones, clays, and ores.

Fluid. Colour white. Sp. gr. about 13.6.

SPECIES

(x) *Kirw.* II. 113.—*Laxmann. Nov. Comm. Petropol.* XIX. 482.—*Monnet. Mem. Sçav. Etrang.* IX. 717.

(y) See *Brownrigg, Phil. Trans.* XLVI. 584.—*Lewis, ibid.* XLVIII. 638. and L. 148.—*Margraf. Mem. Berlin,* 1757, p. 314.—*Macquer, Mem. Par.* 1758, p. 119.—*Buffon, Jour. de Phys.* III. 324.—*Morveau, ibid.* VI. 193.—*Bergman, Opusc.* II. 166.—*Tillet, Mem. Par.* 1779, p. 373, and 385, and 545.—*Crell, Crell's Annals,* 1784, 1 *Band.* 328.—*Willis, Manchester Memoirs,* III. 467.—*Mussin Puschkin, Ann. de Chim.* XXIV 205.—*Morveau, ibid.* XXV. 3.

(z) See *Entrecolle's Lettres Edifiantes.*

(A) See *Molina's Natural History of Chili.*

(B) See *Bowle's Natural History of Spain,* and *Jour. de Min.* N° xxxi. p. 555.

(C) See *Ulloa's Memoirs concerning America.*

Ores of Mercury.

SPECIES 2. Amalgam of silver *.
Native amalgam.

197 Amalgam of silver. This mineral has been found in the silver mine of Sahlberg †, in the province of Dalecarlia, in Sweden; in the mines of Deux Ponts ‡, in the Palatinate; and in other places. It is in thin plates, or grains, or crystallized in cubes, parallelopipeds, or pyramids.

Its colour is silvery white or grey. Lustre metallic. Creaks when cut. Sp. gr. above 10. Tinges gold white. Before the blow-pipe the mercury evaporates and leaves the silver.

A specimen of this amalgam, analysed by Klaproth, contained 64 mercury,
36 silver.

100 §

Sometimes it contains a mixture of alumina, and sometimes the proportion of mercury is so great that the amalgam is nearly as soft as paste.

* *Kirwan*, ii. 223.
† *Cronstedt's Min.*
‡ *Hever Crell's Annals*, 1790.
§ *Beiträge* i 183.

108 G. II. Sulphurets. Common sulphuret.

GENUS II. SULPHURETS OF MERCURY.
SPECIES I. Common sulphuret *.
Native cinnabar.

This ore, which is found in almost all mercurial mines, is sometimes in veins, sometimes disseminated, sometimes in grains, and sometimes crystallized. The form of its crystals is a tetrahedron or three-sided pyramid, most commonly wanting the summit; sometimes two of these pyramids are joined base to base; and sometimes there is a three-sided prism interposed between them †.

Its colour is red. Its streak red and metallic. Lustre when crystallized 2 to 3; when amorphous, often 0. Transparency, when crystallized, from 1 to 3; when amorphous, often 0. Texture generally foliated. Hardness from 3 to 8. Sp. gr. from 5.419 to 10 1285.

Before the blow-pipe evaporates with a blue flame and sulphureous smell. Insoluble in nitric acid ‡.

Variety 1. Dark red.

Colour cochineal red. Hardness 6 to 7. Sp. gr. when pure, 10.1285 §; sometimes only 7.2, or even 6.188 ¶.

Variety 2. Bright red.

Colour commonly scarlet. Sp. gr. 6.9022 † to 5.419 ‡.

* *Kirwan*, ii. 228.
† *Rome de Lisle*, iii. 154.
‡ *Hauy, Jour. de Min.* N° xxxi. p. 515.
§ *Brisson.*
¶ *Muschenbroek.*
† *Brisson.*
‡ *Gellert.*

199 G. III. Oxyds. Hepatic mercurial ore.

GENUS III. OXYDS OF MERCURY.
SPECIES I. Hepatic mercurial ore *.

This ore, which is the most common in the mines of Idria, is always amorphous, and is often mixed with native mercury and cinnabar.

Its colour is somewhat red. Its streak dark red and brighter. Lustre commonly metallic. Hardness from 6 to 8. Sp. gr. from 9.2301 † to 7.186 ‡. When heated the mercury evaporates.

Though this ore has never been accurately analysed, chemists have concluded that the mercury which it contains is in the state of a red oxyd, because it is insoluble in nitric and soluble in muriatic acid ¶. When purest, it contains about .77 of mercury §. It contains also some sulphur and iron.

Werner has divided this species into two varieties, the *compact* and the *slaty*. The second is often nothing more than bituminous shale impregnated with oxyd of mercury †.

* *Kirwan*, ii. 224.
† *Brisson*
‡ *Kirwan.*
¶ *Sage, Jour. de Phys.* xxiv 61.
§ *Scopoli, Jour. de Min.* N° xxxvi. p 919
† *Kirwan*, ii. 226.

GENUS IV. MERCURIAL SALTS.
SPECIES I. Muriat of mercury *
Corneous mercury.

200 Mercurial salts. Muriat of mercury. This ore, which occurs in the Palatinate, is sometimes in scales, sometimes in grains, and sometimes crystallized. Its crystals are either small four or six sided prisms whose sides are rhombs †, or cubes, or four sided pyramids wanting their angles. They are always very small and generally confused.

Its colours are various; but it is most frequently white. Its lustre, when white, is pearly. Sometimes opaque, and sometimes semitransparent. Evaporates before the blow-pipe.

Mr Woulfe discovered, that this ore generally contains some sulphuric acid ‡. Specimens have been found in which the quantity of sulphuric acid exceeds that of the muriatic §.

* *Kirwan*, ii. 226.
† *Jour. de Min.* iii. 161.
‡ [illegible]
§ [illegible]

ORDER V. COPPER ORES.

MANY of the most useful utensils are formed of copper: it enters largely into the composition of brass, bronze, and bell metal; not to mention the dyes and paints of which it is the basis.

201 Mines. Copper mines abound in most countries. They are wrought in China, Japan, Sumatra; the north of Africa; in Chili and Mexico; and in most parts of Europe; especially Britain, Germany, Russia, Hungary.

Copper is found most commonly in rocks of hornblende, shistus, and quartz.

GENUS I. ALLOYS OF COPPER.
SPECIES I. Native copper *.

202 G.I. Alloys. Native copper. Native copper occurs now and then in the greater number of copper mines: Sometimes it is in masses, sometimes in plates and threads, which assume a variety of forms; and sometimes, as in Siberia, it is crystallized in cubes, or other forms nearly resembling cubes †.

Colour commonly that of copper, but sometimes dark brown. Lustre metallic. Streak brighter. Fracture hackly. Flexible and malleable. Hardness 6 to 7. Sp. gr. from 7.6 to 8.5844 ¶.

* *Kirwan*, ii. [illegible]
† *Cronstedt*, [illegible]
¶ *Hauy, Jour. de Min.* N° xxxii. [illegible]

SPECIES 2. White copper ore *.
Alloy of copper, iron, and arsenic.

203 White copper ore. This ore, which is said to be uncommon, occurs in masses. Colour white. Lustre metallic. Fracture uneven. Hardness 8 to 9. Brittle. Sp. gr. considerable.

Before the blow-pipe gives out a white arsenical smoke, and melts into a greyish black slag *.

* *Kirwan's Min.* ii. 152.
* *Wiedeman.*

GENUS II. SULPHURETS OF COPPER.
SPECIES I. Common sulphuret of copper †.
Vitreous copper ore.

204 G. II. Sulphurets. Common sulphuret of copper. This ore, which is found in Cornwall, Hungary, and Siberia, occurs in masses, plates, threads, and crystallized in six-sided prisms, or four sided pyramids, joined base to base.

Colour bluish grey. Streak brighter grey. Lustre metallic. Hardness 4 to 7. Sp. gr. 5.452 to 5.565; sometimes so low as 4.129 *. Detonates with nitre.

Before the blow-pipe it melts easily, and while in fusion exhibits a green pearl, which, on cooling, is covered with a brown crust. Tinges borax green.

Werner makes two varieties of these ores; the first he

† *Kirwan*, ii 134.
* *Kirwan.*

Copper Ores. calls *compact*, from its fracture; and the second, for the same reason, he calls *foliated*. This last is somewhat darker coloured than the first, but in other respects they agree.

205 Copper pyrites

SPECIES 2. Copper pyrites*.
Yellow copper ore.

* Kirwan, ii. 140. This ore, which is probably nothing else than fulphuret of iron combined with copper, and which, therefore, would be more properly placed among iron ores, is found frequently in copper mines, and mixed with common pyrites or fulphuret of iron. It is sometimes amorphous, and sometimes cryftallized. Its cryftals are either three or four fided pyramids applied base to base, or six fided plates.

Its colour is yellow; often tarnished. Its internal lustre metallic. Hardness 6 to 7; sometimes 9. Brittle. Sp. gr. 4.314 † to 4.3 ‡. Deflagrates; but does not detonate with nitre ‖.

† Brisson. ‡ Kirwan. ‖ Id. Min. ii 141.

Before the blow pipe decrepitates, gives a greenish fulphureous smoke, and melts into a black mass, which tinges borax green. Does not effervesce with nitric acid.

206 Purple copper ore.

SPECIES 3. Purple copper ore*.

* Kirwan, ii. 142. This ore is found in masses, or plates, or disseminated; sometimes, also, it is cryftallized in octohedrons. Colour various, but most commonly purple; internally reddish. Streak reddish and bright. Lustre metallic. Hardness 6 to 7. Brittle. Sp. gr. 4.956 to 4.983†.

† Id. ii. 143.

Effervesces with nitric acid, and tinges it green. Deflagrates with nitre. Before the blow-pipe melts readily, without smoke, vapour, or smell; but is not reduced. Tinges borax a bright green.

A specimen of this ore, analysed by Klaproth, contained

58	copper,
18	iron,
19	sulphur,
5	oxygen.
100 ‡	

‡ Beiträge, ii. 286.

207 Grey copper ore

SPECIES 4. Grey copper ore §.

§ Kirwan, ii 146. This ore is found in Cornwal, Saxony, Hungary, &c. It is often amorphous, but often also cryftallized. The primitive form of its cryftals is the regular tetrahedron, but, in general, either the angles or the edges, or both, are truncated or bevelled ‖.

‖ Romé de Lisle, iii. 315

Colour steel grey; often tarnished, and then dark grey. Streak dark grey; sometimes reddish brown. Powder blackish; sometimes with a tint of red. Lustre metallic. Hardness 7 or 8. Very brittle. Sp. gr. 4.8648 *. Deflagrates with nitre. Before the blowpipe crackles, but at last melts, especially if assisted by borax. The bead gives a white smoke, without any particular smell; tinges borax yellow or brownish red, but does not unite with it.

* Hauy, Jour. de Min. N° xxxi. 512.

A specimen of this ore from Cremnitz, analysed by Klaproth, contained

31	copper,
14	silver,
34	antimony,
3	iron,
11	sulphur.

Napion, in an ore from the valley of Lanzo, found copper, silver, and antimony, nearly in the same proportions, but more iron, and some arsenic †. Savoresi, as Baron Born informs us, besides the ingredients of Klaproth's analysis, found some gold and mercury in grey copper ore ‡: and Klaproth himself found lead in most of the other specimens which he examined.

† Mem Turin, v. 173.

‡ Catal. ii. 498.

208 G. III. Oxyds. Red oxyd of copper.

GENUS III. OXYDS OF COPPER.

SPECIES 1. Red oxyd of copper §.
Florid red copper ore—Red copper glass.

This ore is found in Cornwal, and many other countries. It occurs in masses, disseminated, in scales, and cryftallized. The figure of its cryftals is most commonly the regular octohedron *.

§ Kirwan, ii 135.

* Hauy, Jour. de Min N° xxxi. 517.

Colour commonly cochineal red. Streak brick red. Lustre semimetallic. Transparency, when amorphous, generally 0; when cryftallized, 3 or 4. Hardness from 4 to 7. Soluble with effervescence in nitric acid. Before the blow pipe melts easily, and is reduced.

This ore was supposed to be composed of carbonic acid and red oxyd of copper; but a specimen, examined by Vauquelin, which consisted of pure cryftals, contained no acid †. It must therefore be considered as an oxyd of copper.

† Ibid.

Werner has made three varieties of this ore, which, from their texture, he has denominated *compact*, *foliated*, and *fibrous*. The first is seldom or never found cryftallized, and is opaque; the second occurs amorphous, cryftallized, and in scales; the third is carmine, ruby, or scarlet red; and occurs always in short capillary cryftals, or delicate flakes.

This ore sometimes contains a mixture of red oxyd of iron; it is then called *brick red copper ore*, *copper malm*, or *copper ochre*.

This ore is sometimes mixed with bitumen. Its colour is then brownish black, and it is called *pitch ore*.

209 Green oxyd of copper.

SPECIES 3. Green oxyd of copper §.
Green sand of Peru.

§ Kirwan, ii. 149.

This ore, which was brought from Peru by Dombey, is a grass green powder, mixed with grains of quartz. When thrown on burning coals, it communicates a green colour to the flame. It is soluble both in nitric and muriatic acids without effervescence. The solution is green. It was supposed to contain muriatic acid *; but Vauquelin has discovered, that the appearance of this acid was owing to the presence of some common salt, which is accidentally mixed with the sand ‡.

* Berthollet, Mem. Par. 1786, 462.

‡ Jour de Min. N° xxxi. 519.

210 G. IV Salts. Blue carbonat of copper.

GENUS IV. SALTS OF COPPER.

SPECIES 1. Blue carbonat of copper (D).
Mountain blue—Azur de cuivre—Blue calx of copper—Kupfer lazur.

This ore, which occurs in the copper mines of Siberia, Sweden, Germany, Hungary, Cornwal, &c. is either amorphous or cryftallized. The cryftals are small, and difficult to examine. According to Romé de Lisle, their primitive form is an octohedron, the sides of which are isosceles triangles, and two of them more inclined than the others §. Be that as it may, the cryftals of blue carbonat of copper are often rhomboidal prisms, either regular, or terminated by dihedral summits *.

§ Cryftal. iii. 343

* Ibid p. 345.

Its colour is azure or smalt blue. Streak blue. Hardness

(D) *Kirw.* II. 129.—*Morveau*, *Mem. Dijon*, 1782. 1 *Semestre*, p. 100.

Copper Ores. Brazil. nefs 4 to 6. Brittle. Sp. gr. 3.608 ‡. It effervefces with nitric acid, and gives it a blue colour. Before the blow-pipe it blackens, but does not melt. Tinges borax green with effervefcences.

The cryftals, according to Pelletier, are compofed of

66 to 70 copper,
18 — 20 carbonic acid,
8 — 10 oxygen,
2 — 2 water.

Fontana firft difcovered that this ore contained carbonic acid gas

Variety 1. Earthy blue carbonat.

Mountain blue.

This variety generally contains a mixture of lime. It is never cryftallized; and fometimes is almoft in the ftate of powder. Luftre 0. Texture earthy.

Variety 2. Striated blue carbonat of copper.

Luftre glaffy. Tranfparency, when cryftallized, 2; when amorphous, 1. Texture ftriated; fometimes approaching to the foliated.

211 Green carbonat of copper. SPECIES 2. Green carbonat of copper (E).

Oxygenated carbonat of copper—Malachite.

This ore is generally amorphous, but fometimes it is cryftallized in four-fided prifms, terminated by four-fided pyramids.

Colour green. Luftre filky. Hardnefs 5 to 7. Brittle. Sp. gr 3.571 * to 3.653 ‡. Effervefces with nitric acid, and gives a blue colour to ammonia. Before the blow pipe it decrepitates and blackens, but does not melt. Tinges borax yellowifh green. It is compofed of carbonic acid and green oxyd of iron.

* Briffon. ‡ Kirwan.

Variety 1. Fibrous malachite.

Texture fibrous. Opaque when amorphous; when cryftallized its tranfparency is 2. Colour generally grafs green.

Variety 2. Compact malachite.

Texture compact. Opaque. Colour varies from the dark emerald green to blackifh green.

A fpecimen of malachite from Siberia, analyfed by Klaproth, contained

58.0 copper,
18.0 carbonic acid,
12.5 oxygen,
11.5 water.

100 *

* Beitrüge, 290.

This fpecies is fometimes mixed with clay, chalk, and gypfum, in various proportions; it is then known by the name of

Common mountain green.

Its colour is verdigris green. Luftre 0. Tranfparency 0 to 1. Hardnefs 3 to 4. Brittle. Texture earthy. Effervefces feebly with acids. Before the blow-pipe it exhibits the fame phenomena with malachite.

212 Sulphat of copper. SPECIES 3. Sulphat of copper.

For a defcription of this falt, fee CHEMISTRY, n° 648. in this *Supplement.*

213 Arfeniat of copper. SPECIES 4. Arfeniat of copper ‡.

Olive copper ore.

This ore is found at Carrarach in Cornwal. It is generally cryftallized in fix-fided compreffed prifms. Its colour is olive green. Streak fometimes ftraw coloured, fometimes olive green. Luftre glaffy. Tranfparency from 4 to 2. Fracture conchoidal. Hardnefs 4 to 7. Before the blow pipe deflagrates with an arfenical fmoke, and melts into a grey coloured bead. This bead, fufed with borax, leaves a button of pure copper ‖.

‡ Kirwan, 151.

Metallic Ores.

Klaproth difcovered that it was compofed of oxyd of copper and arfenic acid.

‖ Klaproth's Obfervations on Cornwal, p. 29.

Sometimes this ore is combined with iron. It then cryftallizes in cubes. Thefe cubes are of a dark green colour; before the blow pipe they froth, give out an arfenical fmoke, and do not fo quickly form a grey bead as the arfeniat of copper *.

* Ibid. p. 29.

ORDER VI. IRON ORES.

To defcribe the ufes of iron, would be to write the hiftory of every art and manufacture, fince there is not one which is not more or lefs dependent upon this ufeful metal. Nor is its abundance inferior to its utility. It exifts almoft everywhere, and feems, as it were, the bond which connects the mineral kingdom together. 214 Iron.

GENUS I. ALLOYS OF IRON

215 G. I. Alloys. Native iron.

SPECIES 1. Native iron (F).

Native iron has been found in Siberia and in Peru in immenfe maffes, which feemed as if they had been fufed. Thefe maffes evidently did not originate in the place where they were found. See *Fire-Balls, Suppl.*

Colour bluifh white Fracture hackly Luftre metallic. Malleable. Magnetic Hardnefs 8 to 9. Sp. gr. 7.8. Prouft has difcovered, that the native iron found in Peru is alloyed with nickel ¶.

¶ Nicholfon's Jour. III. 374.

GENUS II. SULPHURETS OF IRON.

SPECIES 1. Common fulphuret of iron *.

Pyrites.

216 G. II. Sulphurets. Common fulphuret of iron.

This mineral occurs very frequently both in ores and mixed with other bodies, for inftance in flates. It is often amorphous, and often alfo cryftallized. The primitive form of its cryftals is either a regular cube or an octohedron. The varieties of its form hitherto defcribed amount to 30; for a defcription of which we refer the reader to *Rome de l'Ifle* †.

* Kirwan, ii 76.—Henkel's Pyritology.

Its colour is yellow. Its luftre metallic. Hardnefs 8 to 10. Brittle Sp gr. 3.44 to 4.6. Soluble in nitric acid with effervefcence. Scarce foluble in fulphuric acid. Before the blow-pipe burns with a blue flame and a fulphureous fmell, and leaves a brownifh bead, which tinges borax of a fmutty green.

Variety 1. Common pyrites.

Fracture uneven Hardnefs 10. Decrepitates when heated. Emits a fulphureous fmell when rubbed Not magnetic. It occurs often in coal mines and in flates.

Variety 2. Striated pyrites.

Texture ftriated. Hardnefs 10. Not magnetic.

Variety 3. Capillary.

Colour often fteel grey. Found in needle-form cryftals. Uncommon. Not magnetic.

Variety 4. Magnetic pyrites.

Found in maffes. Texture compact. Hardnefs 8, 9. Slightly magnetic. Seems to contain lefs fulphur than the other varieties.

In pyrites the proportion of the fulphur to the iron is variable, and this explains the variety of its cryftalline forms.

GEN

(E) *Kirw* II. 131.—*Fontana, Jour. de Phyf.* XI. 509.—*Klaproth, Beiträge,* II. 287.

(F) *Pallas, Phil. Tranf.* LXVI. 523.—*Rubin de Celis, ibid.* LXXVIII. 37.—See alfo *Schreiber, Jour. de Phyf.* XLI. 3.; and *Stelin, Phil. Tranf.* LXIV. 461.

Iron Ore.

GENUS III. CARBURET OF IRON.

217 G. III. Plumbago.

SPECIES 1. Plumbago *.

Graphite of Werner.

* Kirwan, i. 155.

This mineral is found in England, Germany, France, Spain, America, &c. It occurs in kidney form lumps of various sizes. Its colour is dark iron grey or brownish black; when cut, bluish grey. Lustre metallic, from 3 to 4. Opaque. Structure scaly. Texture fine grained. Hardness 4 to 5. Brittle. Sp. gr. from 1.987 to 2.089; after being soaked in water 2.15; after being heated 2.3, and when heated after that 2.41†. Feels somewhat greasy. Stains the fingers, and marks strongly. The use of this mineral when manufactured into pencils is known to every person.

† Brisson.

Its composition was discovered by Scheele. When pure it contains
90 carbon,
10 iron.

100

But it is often exceedingly impure: A specimen, for instance, from the mine of Pluflier, in France, analysed by Vauquelin, contained
23 carbon,
2 iron,
38 silica,
37 alumina.

100 ‡

‡ Jour. de Min. No xii. p. 16.

GENUS IV. IRON COMBINED WITH SILICA.

218 G. IV. Emery.

SPECIES 1. Emery *.

* Kirwan, ii. 193.

This mineral is commonly disseminated through other fossils, but sometimes in the East Indies it occurs in large masses.

Its colour is bluish grey, greyish brown, or bluish black, often covered with a yellowish rind; internally it discovers red or purple spots. Lustre 1 or 0; in some parts 2, and metallic. Opaque. Hardness 14. Brittle. Sp. gr. 3.92†. Before the blow pipe it blackens and gives a smutty yellow tinge to borax.

† Wiegleb.

According to Wiegleb it contains
95.6 silica,
4.3 iron.

99.9

GENUS V. OXYDS OF IRON.

This genus is very extensive: for iron is much more frequently found in the state of an oxyd than in any other.

219 Black oxyd of iron.

SPECIES 1. Black oxyd of iron ‡.

‡ Kirwan, ii. 158.

Common magnetic iron stone—Blackish octohedral iron ore.

This species of ore is very common in Sweden; it is found also in Switzerland, Norway, Russia, &c. It occurs in masses, plates, grains, and crystallized. The primitive form of its crystals is a regular octohedron ‡. Sometimes two opposite sides of the pyramids are trapeziums, which renders the apex of the pyramids cuneiform. Sometimes the crystals pass into rhomboidal parallelopipeds, and into dodecahedrons with rhomboidal faces §.

‡ Romé de Lisle, iii. 178.

§ Ibid.

* Hauy, Jour. de Min. No xxviii. 652.

Its surface is brownish black; internally bluish grey. Powder black *. Streak bluish grey, brighter. Lustre metallic. Hardness 9 to 10. Brittle. Sp. gr. from 4.094 to 4.038†. Attracted by the magnet, and generally possessed of more or less magnetic virtue ‡. To this species belongs the magnet. Before the blow-pipe it becomes browner, but does not melt. Tinges borax dark green.

† Kirwan's Min. i. 50.

‡ Hauy, Jour. de Min. No xxiii. 523.

Metallic Ores.

When pure it consists entirely of oxyd of iron; and this oxyd appears to contain from .15 to .24 oxygen, and from .76 to .85 iron §. Undoubtedly it consists of a mixture of iron in two different states of oxydation. It is often also mixed and contaminated with foreign ingredients.

§ Kirwan's Min. ii. 159.

There are two varieties of this ore. The first is what we have just described; the second is in the form of sand, and has therefore been called

Magnetic sand *.

* Kirwan, ii.—Dupuget, Jour. de Min. No xxi. p 75.

This substance is found in Italy, Virginia, St Domingo, the East Indies, and in the sand of the river Don at Aberdeen in Scotland. It is black, very hard, magnetic. Sp. gr. about 4.6. Not altered by the blowpipe *per se*; melts into a black glass with potass, and into a green glass with microcosmic salt, both opaque†. It probably contains some silica, as Kirwan has supposed ‡.

† Fourcroy, Ann. de Chim. ii. 127.

‡ Min. ii. 161.

221 Specular iron ore.

SPECIES 2. Specular iron ore ¶.

Fer oligiste.

¶ Kirw. ii. 162.—Coudrai, Jour. d. Phys. iv. 52.

This ore is found abundantly in the isle of Elba near Tuscany. It is either in masses or crystallized. The primitive form of its crystals, and of its integrant molecules, is the cube *. The varieties hitherto observed amount to 7. These are the rhomboidal parallelopiped; the cube, with three triangular faces instead of two of its angles diagonally opposite; two six-sided pyramids, applied base to base, wanting the summits ‡, and sometimes the angles at the bases, and sometimes the alternate edges of the pyramid; a polyhedron of 24 sides, resembling a cube with three triangular faces for two angles diagonally opposite, and two triangles for the rest of its angles. For a description and figure of these varieties, we refer to *Romé de Lisle*† and *Hauy*†.

* Hauy, Jour. de Min. No xxxiii. 660.

‡ Fig. 39.

† Cryst. iii. 189.

† Ibid. 660.

Colour steel grey; often tarnished, and beautifully iridescent, reflecting yellow, blue, red. Streak red. Powder dark red. Lustre metallic. Hardness 9 to 10. Not brittle. Sp. gr. 5.0116† to 5.218‡. Slightly magnetic. Little altered by the blow-pipe. Tinges borax an obscure yellow.

† Hauy.

‡ Brisson.

This ore, according to Mr Mushet, is composed of
66.1 iron,
21.2 oxygen,
10.7 water and carbonic acid,
2.0 lime.

100.0 †

† Phil. Mag. iii. 354.

The quantity of oxygen here stated is probably too small, owing to the unavoidable inaccuracy which results from the *dry way* of analysis which Mr Mushet followed.

Micaceous iron ore

Is generally considered as a variety of this species. Kirwan, however, supposes it to contain carbon, and to be a distinct species.

It is found in Saxony, and in the isle of Elba, &c. generally in amorphous masses, composed of thin six-sided laminae. Colour iron grey. Streak bluish grey. Lustre metallic. Opaque. Feel greasy. Hardness 5 to 7. Brittle. Sp. gr. from 4.5 to 5.07. Slightly magnetic.

Iron Ores.

magnetic. Infusible by the blow-pipe. Tinges borax greenish brown.

222 Laminated specular iron ore.

SPECIES 3. Laminated specular iron ore.

Fer pyrocite of Hauy.

This ore, which is found at Mont d'or in Auvergn, was usually arranged under the last species; but has been separated from it, we think properly, by Mr Hauy, because the form of its crystals is incompatible with the supposition that their primitive nucleus is a cube, as we have seen is the case with common specular iron ore. Its crystals are thin octagonal plates, bounded by six linear trapeziums, alternately inclined different ways†.

Colour steel grey. Powder reddish black. Lustre metallic; surface polished. Fracture glassy. Very brittle ‡. Hauy supposes that this ore has been produced by fire, and accordingly has given it a name which denotes its origin.

† De Lisle, iii. 103.

‡ Hauy, Jour. de Min. N° xxxi. 33.

223 Brown iron ore.

SPECIES 4. Brown iron ore ¶.

This species of ore is found abundantly in Britain, particularly in Cumberland and Lancashire; and it is also very common in other counties. It consists of the brown oxyd of iron, more or less contaminated with other ingredients.

¶ Kirw. ii 163.

Its colour is brown. Its streak reddish brown. Sp. gr. from 3.4771 to 3.951. Before the blow pipe blackens, but does not melt. Tinges borax greenish yellow.

Variety 1. Brown hæmatites.

The name hæmatites (bloodstone) was probably applied by the ancients only to those ores which are of a red colour, and have some resemblance to clotted blood; but by the moderns it is applied to all the ores of iron which give a reddish coloured powder, provided they be of a fibrous texture.

Brown hæmatites occurs in masses of various shapes, and it is said also to have been found crystallized in five or six sided acute angled pyramids. Colour of the surface brown or black, sometimes iridescent; internally nut brown. Powder red. Texture fibrous. Hardness 8 to 10. Brittle. Sp. gr. 3.789† to 3.951‡. Not magnetic.

† Gellert. ‡ Kirwan.

This variety has not been analysed, but it seems to consist of brown oxyd of iron, oxyd of manganese, and alumina ¶.

¶ Kirwan's Min. ii. 164.

Variety 2. Compact brown iron stone.

This variety occurs in masses of very various and often fantastical shapes.

Colour brown. Internal lustre metallic. Texture compact. Hardness 6 to 9. Brittle. Sp. gr. 3.4771† to 3.551‡.

† Brisson. ‡ Kirwan.

Variety 3. Brown Scaly iron ore.

This variety is generally incumbent on other minerals. Colour brown. Lustre metallic. Stains the fingers, marks strongly. Feels unctuous. Texture foliated. Hardness 3 to 5. Brittle. So light as often to float on water.

Variety 4. Brown iron ochre.

This variety occurs both massive and disseminated. Colour from nut brown to orange. Lustre 0. Strongly stains the fingers. Texture earthy. Hardness 3 to 4. When slightly heated reddens.

224 Red iron ore.

SPECIES 5. Red iron ore†.

† Kirw. ii. 168.

Colour red. Streak blood red. Sp. gr. from 3.423 to 5.005. Before the blow pipe blackens, but does not melt. Tinges borax yellowish olive green. When digested in ammonia, it becomes black and often magnetic.

Variety 1. Red hæmatites.

Found in masses, and all the variety of forms of stalactites. Colour between brownish red and steel grey. Powder red. Internal lustre metallic. Texture fibrous. Hardness 9 to 10. Brittle. Sp. gr. 4.74†† to 5.005‡.

†† Gellert. ‡ Kirwan.

When pure it consists of red oxyd of iron, but it often contains manganese and alumina §.

§ Kirwan's Min. ii. 169.

Variety 2. Compact red iron ore.

Found massive and stalactitic; sometimes in crystals of various forms, but they seem to be only secondary; sometimes in columns like basalt.

Colour between brown red and steel grey. Stains the fingers. Lustre 1 to 0; often semimetallic. Texture compact. Hardness 7 to 9. Brittle. Sp. gr. 3.423 to 3.76† Sometimes invested with a rosy red ochre.

† Kirwan.

Variety 3. Red ochre.

Found sometimes in powder, sometimes indurated. Colour blood red. Stains the fingers. Lustre 0. Texture earthy. Hardness 3 to 5. Brittle.

Variety 4. Red scaly iron ore.

This variety is generally found incumbent upon other iron ores. Colour between cherry red and steel grey. Stains the fingers. Lustre silky, inclining to metallic. Texture foliated. Feels unctuous. Hardness 3 to 4. Brittle. Heavy.

225 Argillaceous iron ore.

SPECIES 6. Argillaceous iron ore ‡.

Oxyd of iron combined or mixed with [illegible].

This ore is exceedingly common; and though it contains less iron than the species already described, it is, in this country at least, preferred to them, because the method of extracting pure iron from it is easier, or rather because it is better understood.

‡ Kirw. ii. 173.

Colour most commonly dark brown. Streak red or yellowish brown. Sp. gr. from 2.673 to 3.471 †. Before the blow pipe blackens, and tinges borax olive green and blackish. It is composed of oxyd of iron, alumina, lime, silica in various proportions. It generally yields from 30 to 40 *per cent.* of iron.

† Kirwan.

Variety 1. Common argillaceous iron ore.

The minerals arranged under this variety differ considerably from each other in their external character. They are found in masses of various shapes, and often form large strata.

Colour various shades of grey, brown, yellow, and red. Streak reddish yellow or dark red. Lustre 0. Hardness from 3 to 8. Smells earthy when breathed upon.

Variety 2. Columnar or [illegible]form iron ore.

This variety is found in columns, adhering to each other, but easily separable: They are commonly incurvated, and their surface is rough. Colour brownish red. Streak dark red. Slightly stains the fingers. Lustre 0. Adheres strongly to the tongue. Sound hollow. Feel dry. Texture earthy.

Variety 3. Acinose iron ore.

This variety is found in masses, and is commonly lenticular. Colour generally brownish red. Lustre metallic, nearly. Texture granular. Hardness 5 to 6. Brittle.

Variety

Iron Ores.

Variety 4. Nodular, or kidney-form iron ore.
Ætites or *Eagle-stone*.

This variety, which was mentioned by the ancients, is generally found under the form of a rounded knob, more or less resembling a kidney, though sometimes it is quadrangular; and it contains within it a kernel, which is sometimes loose, and sometimes adheres to the outside rind. Colour of the stone yellowish brown; of the kernel ochre yellow. Surface generally fouled with earth. Lustre of the rind metallic; of the kernel 0. Hardness from 4 to 7. Brittle.

Variety 5. Pisiform or granular iron ore.

This variety occurs in rounded masses, from the size of a pea to that of a nut. Surface rough. Colour commonly dark brown. Streak yellowish brown. Hardness 5 to 6. Brittle.

The oolitic ore found at Creusot, near mount Cenis, belongs to this variety. It is composed of

50 lime,
30 iron,
20 alumina.
———
100

226 Lowland iron ore. * Kirw. ii. 179.

SPECIES 7. Lowland iron ore *.

This species of ore is supposed to consist of oxyd of iron, mixed with clay and phosphuret or phosphat of iron. It is called lowland ore, because it is found only in low grounds; whereas the last species is more commonly in high grounds; and is therefore called *highland ore*.

This ore occurs in amorphous masses, and also in grains or powder. Its colour is brown. Streak yellowish brown. Lustre 0, or common. Texture earthy. Hardness 3 to 5.

Variety 1. Meadow lowland ore.

Colour blackish or yellowish brown: Both colours often meet in the same specimen. Found in lumps of various sizes, often perforated. Fracture compact. Moderately heavy.

Frequently yields from 32 to 38 *per cent.* of iron.

Variety 2. Swampy iron ore.

This variety is generally found under water. It is in lumps, which are commonly perforated or corroded, and mixed with sand. Colour dark yellowish brown, or dark nut brown. Hardness 3 to 4. Brittle. Sp. gr. 2.944. It often contains .36 of iron.

Variety 3. Morassy iron ore.

This variety is found either in a loose form or in perforated lumps. Colour light yellowish brown. Stains the fingers. Hardness 3. Friable.

227 G. VI. Salts. Sparry iron ore.

GENUS VI. SALTS OF IRON.

SPECIES 1. Sparry iron ore (G).

This ore is common in Germany, France, and Spain. It is found sometimes in amorphous masses, and sometimes crystallized.

Its colour is white; but it becomes tarnished by exposure to the air, and then assumes various colours. Streak grey or white. External lustre often metallic; internal common or glassy. Transparency 1 or 2; sometimes 0. Texture foliated. Fragments rhomboidal. Hardness 5 to 7. Brittle. Sp. gr. 3.6 to 3.81. Not magnetic. Soluble in acids with very little effervescence. Before the blow-pipe decrepitates, becomes brownish black, and magnetic; but is scarcely fusible. Tinges borax smutty yellow, with some effervescence.

This ore, as Bergman ascertained, consists of iron, manganese, lime, and carbonic acid.

One specimen, according to his analysis, contained

38 iron,
24 manganese,
38 carbonat of lime.
———
100

Another contained 22 iron,
28 manganese,
50 carbonat of lime.
———
100

Whether the iron be combined with the carbonic acid is still a disputed point. The crystals of this ore are rhomboidal parallelopipeds; which is precisely the form of carbonat of lime. This amounts nearly to a demonstration, that the carbonic acid is combined with the lime; and that, as Cronstedt and Hauy have supposed, this ore is merely carbonat of lime, contaminated with a quantity of the oxyds of iron and manganese.

228 Arseniat of iron.

SPECIES 2. Arseniat of iron.

Mr Proust has discovered this ore in Spain. Its colour is greenish white. Its texture granular. Insoluble in water and nitric acid. When melted on charcoal, the arsenical acid escapes with effervescence ‡.

‡ Ann. de Chim. i. 195.

229 Sulphat of iron.

SPECIES 3. Sulphat of iron.

For a description of this salt, see CHEMISTRY, n° 631. in this *Suppl.*

ORDER VII. TIN ORES (H).

TIN is employed to cover plates of iron and copper, and to silver the backs of looking glasses: It enters into the composition of pewter; and forms a very important article in dyeing.

230 Mines.

Tin ores are by no means so common as the ores of the metals which we have already described. They are found only in the *primitive mountains* (I). Hence Werner supposes them to be the most ancient of all metallic ores. They occur most frequently in granite, sometimes in porphyry, but never in limestone.

Almost

(G) *Kirw.* II. 19[illegible].—*Bergman*, II. 184.—*Bayen. Jour. de Phys.* VII. 213.—*Razoumowski, Mem. Lausanne*, 1783, p. 149.

(H) *Geoffroy, Mem. Par.* 1738, p. [illegible].—*Morveau, Ann. de Chim.* XXIV. 127.

(I) Geologists have divided mountains into three classes; *primitive*, *secondary*, and *tertiary*. The *primitive* occupy the centre of all extensive chains; they are the highest, the most rugged, and exhibit the most pointed tops. They are considered as the most ancient mountains of the globe.

The *secondary* mountains occupy the outside of extensive ranges. They are usually composed of strata, more or less inclined, and commonly rest against the sides of the primitive mountains.—The *tertiary* mountains are much smaller than the others, and are often solitary. We use the terms *primitive*, *secondary*, &c. merely as

proper

Tin Ores.

Almost the only tin mines known to Europeans are those of Cornwal, Devonshire, Saxony, Bohemia, Silesia, Hungary, Gallicia; those of the island of Banca and the peninsula of Malacca in India; and those of Chili and Mexico in America.

231 G. I. Sulphurets. Sulphuret of tin and copper.

GENUS I. SULPHURETS OF TIN.

SPECIES 1. Sulphuret of tin and copper *.

Tin pyrites.

Hitherto this ore has only been found in Cornwal. There is a vein of it in that county, in the parish of St Agnes, nine feet wide, and twenty yards beneath the surface †.

Its colour is yellowish grey, passing into the steel grey. Not unlike grey copper ore. Lustre metallic. Hardness 5 to 6. Very brittle. Sp gr. 4.35 ‡. Before the blow-pipe it melts easily, with a sulphureous smell, into a black bead, and deposits a bluish oxyd on the charcoal.

The composition of this ore, as Klaproth informs us, was first discovered by Mr Raspe. According to Klaproth's analysis, it is composed of

34 tin,
36 copper,
25 sulphur,
3 iron,
2 earth.

100 §

* Kirw. ii. 200.
† Klaproth's Cornwall, p. 21.
‡ Klaproth.
§ Id. 58.

232 G. II. Oxyds. Brown oxyd of tin.

GENUS II. OXYDS OF TIN.

SPECIES 1. Brown oxyd of tin *.

Tinstone—Woodtin.

This ore, which may be considered as almost the only ore of tin, occurs in masses, in rounded pieces, and crystallized. These crystals are very irregular. Hauy supposes, that their primitive form is a cube †; but Romé de Lisle, with more probability, makes it an octohedron ‡; and in this opinion Mr Day agrees with him ‖. The octohedron is composed of two four-sided pyramids, applied base to base. The sides of the pyramids are isosceles triangles, the angle at the vertex of which is 70°, and each of the other angles 55°. The sides of the two pyramids are inclined to each other at an angle of 90° §. This primitive form, however, never occurs, but crystals of tinstone are sometimes found, in which the two pyramids are separated by a prism. For a complete description of the varieties of the crystals of tinstone, we refer the reader to *Romé de Lisle* and *Mr Day* *.

Its colour is commonly brown. Streak grey. Hardness 9 to 10. Sp. gr. 6.9 to 7.0. Brittle.

Variety 1. Common tinstone.

Colour dark brown; sometimes yellowish grey, and sometimes nearly white. Streak light grey. Somewhat transparent when crystallized. Hardness 10. Sp. gr. 6.9 to 6.97. Before the blow pipe it decrepitates, and on charcoal is partly reduced. Tinges borax white.

According to Klaproth, it is composed of

77.50 tin,
21.50 oxygen,
.25 iron,
.75 silica.

100.00 †

Variety 2. Woodtin.

This variety has hitherto been found only in Cornwal. It occurs always in fragments, which are generally rounded. Colour brown; sometimes inclining to yellow. Streak yellowish grey. Opaque. Texture fibrous. Hardness 9. Sp. gr. 7.0. Before the blow pipe becomes brownish red; decrepitates when red hot, but is not reduced.

Klaproth obtained from it .63 of tin; and, in all probability, it is an oxyd of tin nearly pure.

* Kirw. ii. 197.
† Jour. de Min. N° xxvii. 176.
‡ Crystallog. iii. 413.
‖ Philos. Mag. iv. 152.
§ Romé de Lisle, ibid.
* Philos. Mag. ibid.
† Beiträge, ii. 256.

Metallic Ores.

ORDER VIII. ORES OF LEAD.

THE useful purposes to which lead in its metallic state is applied, are too well known to require description. Its oxyds are employed in painting, in dyeing, and sometimes also in medicine.

Ores of lead occur in great abundance in almost every part of the world. They are generally in veins; sometimes in siliceous rocks, sometimes in calcareous rocks.

233 G. I. Sulphurets. Galena, or pure sulphuret of lead.

GENUS I. SULPHURETS OF LEAD.

SPECIES 1. Galena, or pure sulphuret of lead ‡.

This ore, which is very common, is found both in masses and crystallized. The primitive form of its crystals is a cube. The most common varieties are the cube, sometimes with its angles wanting, and the octohedron, composed of two four-sided pyramids applied base to base: The summits of these pyramids are sometimes cuneiform, and sometimes their solid angles are wanting ‖.

Its colour is commonly bluish grey, like lead. Streak bluish grey and metallic. Lustre metallic. Sometimes stains

‡ Kirw. ii. 210.
‖ Romé de Lisle, iii. 364.

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proper names, without affirming or denying the truth or falsehood of the theory on which these names are founded. That the reader may have a more accurate idea of the composition of these different classes of mountains, we have subjoined a list of the substances which, according to Werner, enter into the composition of each.

I. PRIMARY MOUNTAINS.

1. Granite,
2. Gneiss,
3. Micaceous shistus
4. Argillaceous shistus,
5. Syenite,
6. Porphyry,
7. Shistose porphyry,
8. Quartz,
9. Primitive limestone,
10. Serpentine,
11. Topaz rock.

II. SECONDARY MOUNTAINS.

1. Argillaceous shistus,
2. Rubble stone,
3. Secondary limestone,
4. Shistose hornblende,
5. Grunstein,
6. Amygdaloid.

III. TERTIARY MOUNTAINS.

Trap,
Argillaceous shistus,
Stratified limestone,
4. Sandstone,
5. Breccia,
6. Coal,
7. Chalk,
8. Sulphat of lime,
9. Rock salt,
10. Ferruginous clay,
11. Potters earth.

Ores of Lead.

stains the fingers. Texture foliated. Fragments cubical. Hardnefs 5 to 7; fometimes even 9. Brittle. Sp. gr. 6.884 to 7.786 §. Effervefces with nitric and muriatic acids. Before the blow-pipe decrepitates, and melts with a fulphureous fmell; part finks into the charcoal.

§ Watfon.

It is compofed of from .45 to .83 lead, and from .086 to .16 of fulphur. It generally contains fome filver, and fometimes alfo antimony aud zinc.

Variety 1. Common galena.

This variety correfponds nearly with the above defcription. Sp. gr. 7.051 to 7.786. Sometimes ftains the fingers.

Compact galena.

Found only in amorpheus maffes. Texture compact, inclining to foliated. Hardnefs 6 to 8. Sp. gr. 6.886 to 7.444. Luftre common. Streak lead grey, brighter and metallic. Often feels greafy, and ftains the fingers.

234 Sulphuret of lead, with filver and antimony

SPECIES 2. Sulphuret of lead, with filver and antimony*.

Plumbiferous antimoniated filver ore.

Found in amorphous maffes. Colour grey. Hardnefs 5 to 6. Brittle. Sp. gr. from 5.2 to 8.

* *Kirw.* ii. 119

Variety 1. Light grey filver ore.

Colour light bluifh grey. Streak light bluifh grey, and brighter Luftre metallic. Texture compact. Before the blow pipe partly evaporates, and leaves a filver bead on the charcoal, furrounded by yellow duft.

According to Klaproth, it contains

48.06 lead,
20.40 filver,
7.88 antimony,
12.35 fulphur,
2.25 iron,
7.00 alumina,
.25 filica.

98.09 †

† *Beiträge*, i. 172.

Variety 2. Dark grey filver ore.

Colour iron grey, verging on black. Powder black, and ftains the fingers. Luftre 0. Texture earthy.

According to Klaproth, it contains

41.00 lead,
21.50 antimony,
29.25 filver,
22.00 fulphur,
1.75 iron,
1.00 alumina,
.75 filica.

97.25 ‡

* *Ibid.* 175.

235 Blue lead ore.

SPECIES 3. Blue lead ore *.

* *Kirw.* ii. 220.

This ore, which is found in Siberia, Germany, and Hungary, and is very rare, occurs fometimes in maffes, and fometimes cryftallized in fix-fided prifms.

Colour between indigo blue aud lead grey; fometimes inclining to black. Internal luftre metallic. Streak brighter. Texture compact. Hardnefs 6. Sp. gr. 5.461 †. Before the blow pipe melts with a low blue flame and a fulphureous fmell, and is eafily reduced.

† *Gellert.*

236 Black lead ore.

SPECIES 4. Black lead ore ‡.

‡ *Kirw.* ii. 221.

This ore, which is found in Germany and Brittanny, and which is fuppofed to be common galena decayed, is fometimes in ftalactites of various forms, and fometimes cryftallized in fix fided prifms, which are generally truncated and confufed.

Metallic Ores

Colour black, often with fome ftreaks of red. Streak light bluifh grey. Internal luftre metallic. Hardnefs 5 to 6. Brittle. Sp. gr. from 5.744 ‖ to 5.77 *. Before the blow-pipe decrepitates, melts eafily, and is reduced.

‖ *Briffon.*
* *Gellert.*

According to the experiments of Laumont, this ore is a fulphuret of lead (or rather fulphuret of oxyd of lead), mixed with fome phofphat of lead.

237 Sulphuret of lead, bifmuth, and filver.

SPECIES 5. Sulphuret of lead, bifmuth, and filver.

This ore, which occurs in the valley of Schapbach in Saxony, was firft taken notice of by Selb, and afterwards defcribed by Weidenmann and Emerling.

Its colour is light bluifh grey. Its luftre metallic. Its fracture uneven. Hardnefs 5. Melts eafily before the blow pipe, emitting fome fmoke, and leaves a filver bead.

A fpecimen, analyfed by Mr Klaproth, contained

33.0 lead,
27.0 bifmuth,
15.0 filver,
16.3 fulphur,
4.3 iron,
0.9 copper.

96.5 †

† *Beiträge*, ii. 297.

238 G. II. Oxyds. Lead ochre.

GENUS II. OXYDS OF LEAD.

SPECIES 1. Lead ochre ‡.

This ore, which is a mixture of the oxyd of lead with various earths, is found maffive, and of various degrees of hardnefs.

‡ *Kirw.* ii. 205.

Its colour is either yellow, grey, or red. Luftre 0. Tranfparency 0 to 1. Hardnefs 6 to 8; fometimes in powder. Sp. gr. from 4.165 to 5.545 §. Texture compact. Effervefces with nitric and muriatic acids. Eafily reduced by the blow-pipe, leaving a black flag, unlefs the lead be mixed with too great a proportion of earth.

§ *Kirwan.*

239 G. III. Salts. Carbonat of lead.

GENUS III. SALTS OF LEAD.

SPECIES 1. Carbonat of lead †.

White lead fpar.

This ore of lead, which is very common, is fometimes in maffes, and fometimes cryftallized. But the cryftallization is in general fo confufed, that the primitive form of the cryftals has not yet been afcertained (κ).

† *Kirw.* ii 203.

Its colour is white. External luftre, waxy or filky, from 3 to 1; internal 1 to 2. Generally fomewhat tranfparent. Hardnefs 5 to 6. Brittle. Sp. gr. from 5.349 ‖ to 6.92 §. Effervefces with nitric and muriatic acids when they are heated. Soluble in fat oils. Blackened by fulphuret of ammonia *. Decrepitates when heated. Before the blow-pipe, in a filver fpoon, it becomes red by the yellow cone of the flame, while the blue cone renders it yellow †. On charcoal it is immediately reduced.

‖ *Kir.*
§ *Gellert.*
* *Pelletier, Ann. de Chim.* ix. 56.
† *Ribbentropp, Ann. de Chim.* xxv. 189.

It contains from .60 to .85 of lead, and from .18 to .24 of carbonic acid. It is generally contaminated with carbonat of lime and oxyd of iron.

SPECIES

(κ) See *Hauy, Jour. de Min.* Nº XXXI. 502. and *Romé de Lifle*, III. 380.

Ores of Lead.

241 Phosphat of lead † Kirw. ii 207.

SPECIES 2. Phosphat of lead †.

This ore, which is found in Siberia, Scotland, England, Germany, Carinthia, Brittany, &c. is sometimes amorphous, and sometimes crystallized. The primitive form of its crystals, according to Romé de Lisle, is a dodecahedron, consisting of a six-sided rectangular prism, terminated by six sided pyramids, the sides of which are isosceles triangles (L). Sometimes the pyramids are truncated, and even altogether wanting. The crystals of this ore are often acicular.

Its colour is commonly green; sometimes yellowish or brownish, or greyish white. Streak commonly greenish white. Powder yellowish. External lustre, waxy, 2 to 3. Somewhat transparent, except when its colour is greyish white. Hardness 5 to 6. Brittle. Sp. gr. from 5.86 * to 6.27 †. Insoluble in water and sulphuric acid, and nearly insoluble in nitric acid; soluble in hot muriatic acid, with a slight effervescence ‡. Before the blow-pipe it easily melts on charcoal, and crystallizes on cooling: with soda the lead is in some measure reduced.

* Brisson. † Klaproth ‡ Fourcroy, Ann. de Chim. ii. 207.

The composition of this ore was first discovered by Gahn.

According to Fourcroy's analysis, a specimen from Erlenbach in Alsace, consists of

96	phosphat of lead,
2	phosphat of iron,
2	water.
100	

Or it contains

79	oxyd of lead,
1	oxyd of iron,
18	phosphoric acid,
2	water.
100 ¶	

¶ Ibid.

242 Arseniat of lead. § Kirw. ii. 209.

SPECIES 3. Arseniat of lead §.

This ore, which has hitherto been found only in Andalusia in Spain, and always in quartz or feldspar, is in small masses. Colour meadow green, often passing into wax yellow. Lustre waxy, 2. Transparency 2. Before the blow-pipe it melts, and retains its colour, and does not crystallize on cooling. When heated to whiteness, the arsenic acid escapes, and the lead is reduced *.

* Proust, Jour de Phys. xxx. 394.

242 Phosphat and arseniat of lead. † Kirw. ii. 210.

SPECIES 4. Phosphat and arseniat of lead.

Arsenio phosphat of lead †.

This ore, which has been found in Auvergne in France, is either in masses, or crystallized in small six-sided prisms, with curvilineal faces.

Colour yellowish green, or shews alternate layers of pale and light green. Powder yellowish. The crystals are somewhat transparent; but when massive, this ore is opaque. Hardness 5 to 7. Brittle. Sp. gr. 6.8465‡. Soluble in hot muriatic acid, but not in nitric. When heated it decrepitates. Before the blow-pipe melts easily, effervesces, emits a white smoke, with an arsenical smell. Some particles of lead are reduced, a brown fluid remains, which crystallizes on cooling like phosphat of lead.

‡ Brisson.

Metallic Ores.

According to Fourcroy, from whom the whole of this description has been taken, it is composed of

65	arseniat of lead,
27	phosphat of lead,
5	phosphat of iron,
3	water.
100 *	

* Ann. de Chim. ii. 23.

243 Molybdat of lead.

SPECIES 5. Molybdat of lead (M).

This ore, which is found in Carinthia and at Leadhills in Scotland, was first mentioned in 1781 by Mr Jacquin (N). It occurs either in masses, or crystallized in cubic, or rhomboidal, or octohedral plates.

Its colour is yellow. Streak white. Lustre waxy. Generally somewhat transparent. Texture foliated. Fracture conchoidal. Hardness 5 to 6. Sp. gr. 5.486 †; when purified from its gangue by nitric acid, 5.706 ‡. Soluble in fixed alkalies and in nitric acid. Communicates a blue colour to hot sulphuric acid. Soluble in muriatic acid, and decomposed by it. Before the blow-pipe decrepitates, melts into a yellowish grey mass, and globules of lead are reduced ||.

† Macquart ‡ Hatchett. || Macquart.

Klaproth first proved that this ore was molybdat of lead.

A very pure specimen, analysed by him, contained

64.42	oxyd of lead,
34.25	molybdic acid.
98.67 ¶	

¶ Beitrage, ii. 275.

According to the analysis of Mr Hatchett, it is composed of

58.40	oxyd of lead,
38.00	molybdic acid,
2.10	oxyd of iron,
.28	silica.
98.78 *	

* Phil. Trans. lxxxvi. 32.

Macquart found a specimen to contain

58.74	lead,
4.76	oxygen,
28.00	molybdic acid,
4.50	carbonat of lime,
4.00	silica.
100.00 †	

† Jour de Min N° xvii. 32.

Its gangue is carbonat of lime.

244 Sulphat of lead.

SPECIES 6. Sulphat of lead ‡.

This ore, which is found in Anglesey and in Andalusia, is generally crystallized. The crystals are regular octohedrons §, and very minute.

Colour white. Lustre 4. Transparency 4. Before the blow-pipe it is immediately reduced.

The composition of this ore was first ascertained by Dr Withering.

‡ Kirw. Min ii. 211. § Hauy, Jour. de Min N° xxxi 508.

Order IX. ORES OF ZINC.

Hitherto zinc has not been applied to a great variety of uses. It enters into the composition of brass; it is used in medicine; and Morveau has shewn that its oxyd

(L) *Cryst.* III. 391. See also *Hauy's* remarks on the same subject in the *Jour. de Min.* N° XXXI. 506.
(M) *Kirw.* II. 212.—*Klaproth, Ann. de Chim.* VIII. 103.—*Hatchett, Phil. Trans.* 1796, p. 285.
(N) In his *Miscellanea Austriaca*, Vol. II. p. 139.

Ores of Zinc.

oxyd might be employed with advantage as a white paint.

Ores of zinc are very abundant; they generally accompany lead ores, particularly galena. Calamine, or oxyd of zinc, has never been discovered in the primitive mountains.

245 G. I. Sulphurets Common sulphuret of zinc.

GENUS I. SULPHURETS OF ZINC.

SPECIES 1. Common sulphuret of zinc*.

Blende.

This ore very commonly accompanies sulphuret of lead. It occurs both in amorphous masses and crystallized. The primitive form of its crystals is a rhomboidal dodecahedron, consisting of a six sided prism, terminated by three-sided pyramids. All the faces of the crystals are equal rhombs. This dodecahedron may be mechanically divided into four equal rhomboidal parallelopipeds, and each of these into six tetrahedrons, whose faces are equal isosceles triangles. The figure of its integrant particles is the tetrahedron, similar to these*.

The principal varieties of its crystals are the tetrahedron; the octohedron; the octohedron with its edges wanting*; a 24 sided crystal, 12 of whose faces are trapezoids, and 12 elongated triangles†; and, lastly, a 28-sided figure, which is the last variety, augmented by four equilateral triangles†.

Colour yellow, brown, or black. Streak reddish, brownish, or grey. Lustre commonly metallic. Generally somewhat transparent. Texture foliated. Hardness 6 to 8. Sp. gr 3.92‡ to 4.1665¶. Before the blow-pipe decrepitates, and gives out white flowers of zinc, but does not melt. Borax does not affect it. When breathed upon, loses its lustre, and recovers it very slowly||.

* Kirw. ii. 238.—Berg. ii. 329.

* Hauy, Jour. de Min. No xxxiii. 669.

* Fig. 40

† Fig 41.

† See Hauy, ibid and Romé de Lisle, iii 6.

‡ Gellert.

¶ Brisson.

|| Hauy, Jour de Min. ibid.

Variety 1. Yellow blende.

Colour commonly sulphur yellow, often passing into olive green or brownish red. Powder pale yellow. Streak yellowish or reddish grey, not metallic. Lustre metallic. Transparency 2 to 4. Often phosphoresces when scraped or rubbed*.

According to Bergman, it is composed of

64	zinc,
20	sulphur,
5	iron,
4	fluor acid,
1	silica,
6	water.
100†	

* Bergman, ii. 345.

† Ibid. 347.

Variety 2. Brown blende.

Colour different shades of brown. Surface often tarnished. Powder brownish grey. Streak reddish or yellowish grey, not metallic. Lustre commonly metallic. Transparency 0 to 2.

A specimen of this variety, analysed by Bergman, contained

44	zinc,
17	sulphur,
24	silica,
5	iron,
5	alumina,
5	water.
100‡	

‡ Ibid. 333.

Variety 3. Black blende.

Colour black, or brownish black; surface often tarnished blue; tips of the crystals often blood red. Powder brownish black. Streak reddish, brownish, or grey. Lustre common or metallic. Transparency 0 to 1; the red parts 2. Hardness 8.

A specimen of this variety, analysed by Bergman, contained

52	zinc,
26	sulphur,
4	copper,
8	iron,
6	silica,
4	water.
100‡	

Metallic Ores.

‡ Bergman, ii. 335.

246 G. II. Oxyds. White oxyd of zinc.

GENUS II. OXYDS OF ZINC.

SPECIES 1. White oxyd of zinc†.

Calamine.

This ore is either found loose, or in masses, or crystallized. The primitive form of its crystals appears, from the mechanical division of one of them by Mr Hauy, to be an octohedron composed of two four-sided pyramids, whose sides are equilateral triangles†. But the crystals are minute, and their figure not very distinct They are either four or six sided tables with bevelled edges, six-sided prisms, or three-sided pyramids.

Colour commonly white, grey, or yellow. Lustre often 0, sometimes 2 or 1. Opaque. The crystals are somewhat transparent. Hardness from 4 to 9, sometimes in powder. Sp. gr. from 2.585 to 3.674‡. When heated, becomes electric, without friction, like the tourmaline†. Not blackened by sulphuret of ammonia. Soluble in sulphuric acid. Before the blow-pipe decrepitates, and does not melt.

† Kirw. ii. 233.—Berg. ii. 321.

† Jour. de Min. No. xxxii. 596.

‡ Kirwan.

† Hauy, Jour. de Min. ibid.

This ore consists of oxyd of zinc more or less contaminated with iron, silica, lime, and other foreign ingredients. In one specimen Bergman found the following ingredients:

84	oxyd of zinc,
3	oxyd of iron,
12	silica,
1	alumina.
100 ¶	

¶ Bergman, ii. 323.

In another specimen, which gelatinized with acids, like zeolite, Klaproth found 66 oxyd of zinc,

33	silica.
99	

In another specimen, analysed by Pelletier, the contents were

52	silica,
36	oxyd of zinc.
12	water.
100 *	

* Jour. de Phys. xx. 428.

Mr Kirwan has divided this species into three varieties.

Variety 1. Friable calamine.

In masses which easily crumble between the fingers. Lustre 0. Opaque. Texture earthy. When its colour is white, it is pure oxyd of zinc; when yellow, it is mixed with oxyd of iron. The white often becomes yellow when placed in a red heat, but resumes its colour on cooling. Common in China, where it is called *wohan* or *ore of Tutenago.*

Ores of Antimony

Variety 2. Compact calamine.

Colour different shades of grey; sometimes yellow or brownish red. Lustre 0. Opaque. Texture compact.

Variety 3. Striated calamine.

This variety alone is found crystallized; but, like the others, it is also often amorphous. Colour white, and also various shades of grey, yellow, and red. Somewhat transparent. Texture striated. Lustre 2 to 1.

247 G. III. Salts. Sulphat of zinc.

GENUS III. SALTS OF ZINC.

SPECIES 1. Sulphat of zinc.

For a description of this salt, we refer to CHEMISTRY, n° 643. *Suppl.*

ORDER X. ORES OF ANTIMONY.

ANTIMONY is much used to give hardness to those metals which otherwise would be too soft for certain purposes: printers types, for instance, are composed of lead and antimony. It is used also in medicine.

Ores of antimony are found abundantly in Germany, Hungary, France, Spain, Britain, Sweden, Norway, &c. They often accompany galena and hæmatites. They are found both in the secondary and primitive stratified mountains. Their gangue (o) is often quartz and sulphat of barytes.

248 G. I. Alloys Native antimony. * Kirw. ii. 245.

GENUS I. ALLOYS OF ANTIMONY.

SPECIES 1. Native antimony *.

This mineral, which was first discovered by Dr Swab, has been found in Sweden and in France, both in masses and kidney-shaped lumps. Colour white, between that of tin and silver. Lustre metallic. Texture foliated. Hardness 6. Sp. gr. above 6. Deflagrates with nitre. Before the blow-pipe melts and evaporates, depositing a white oxyd of antimony.

It consists of antimony, alloyed with 3 or 4 *per cent.* of arsenic.

249 G. II. Sulphurets. Grey ore of antimony. * Kirw. ii. 247.

GENUS II. SULPHURETS OF ANTIMONY.

SPECIES 1. Grey ore of antimony *.

This ore, which is the most common, and indeed almost the only ore of antimony, occurs both massive, disseminated, and crystallized. Its crystals are four-sided prisms, somewhat flattened, whose sides are nearly rectangles, terminated by short four-sided pyramids, whose sides are trapeziums †. Sometimes two of the edges are wanting, which renders the prism six-sided ‡.

Colour grey. Lustre metallic. Streak grey, metallic, and brighter. Powder black or greyish black. Hardness 6 to 7. Sp. gr. from 4.1327 to 4.516 ¶. Often stains the fingers. Before the blow pipe melts easily, burns with a blue flame, and deposits a white oxyd on the charcoal. When placed in an open vessel, over a slow fire, the sulphur evaporates, and leaves a grey oxyd of antimony. This oxyd, if fused with tartar, is reduced.

† *Romé de Lisle*, iii. 49

‡ *Ibid.*—See also Hauy, *Jour. de Min.* N° xxii. 706.

¶ *Brisson.*

This ore, when taken out of the mine, almost always contains a large proportion of quartz or other stony matter. When pure, it is composed of about

Metallic Ores.

74 antimony,
26 sulphur.
———
100

Werner has divided this species into three varieties.

Variety 1. Compact sulphuret.

Colour bluish grey, surface often tarnished, and then it is blue or purplish. Lustre 1 to 2. Texture compact. Fracture fine grained, uneven. Powder black, dull, and earthy. Slightly stains the fingers.

Variety 2. Foliated sulphuret.

Colour light steel grey. Lustre 3 to 4. Texture foliated. Powder as that of the last variety.

Variety 3. Striated sulphuret.

Colour dark steel grey, and light bluish grey; surface often tarnished, and then it is dark blue or purplish. Lustre 3 to 2. Texture striated Powder greyish black. This variety alone has been hitherto found crystallized.

250 Plumose antimonial ore. † Kirw. ii. 251.

SPECIES 2. Plumose antimonial ore †.

Sulphurets of antimony and arsenic.

This species, which is sometimes found mixed with the crystals of sulphurated antimony, is in the form of brittle, capillary, or lanuginous crystals, often so small that they cannot be distinctly seen without a microscope.

Colour steel or bluish grey, often tarnished, and then brown or greyish black. Lustre 1, semimetallic. Before the blow-pipe emits a smoke, which deposits a whitish and yellowish powder on the charcoal: it then melts into a black slag.

It is supposed to consist of sulphur, antimony, arsenic, and some silver.

251 Red antimonial ore. † Kirw. ii 250.

SPECIES 3. Red antimonial ore †.

Hydrosulphuret of antimony.

This species is generally found in cavities of sulphurated antimonial ore. It is crystallized in delicate needles, often diverging from a common centre.

Colour red. Lustre 2, silky. Sp. gr. 4.7. Before the blow-pipe melts easily, and evaporates with a sulphureous smell.

This ore has not been analysed. Mineralogists have supposed it to be a natural kermes. If so, we may conclude, from the experiments of Berthollet *, that it is a hydrosulphuret of antimony, and consequently composed of oxyd of antimony, sulphur, and sulphurated hydrogen gas.

* *Ann. de Chim.* xxv. 259.

252 G. III. Oxyds of antimony

GENUS III. OXYDS OF ANTIMONY.

There is a substance found incumbent on sulphuret of antimony, of a yellow colour, and an earthy appearance, which has been supposed an oxyd of antimony, and denominated antimonial ochre. But hitherto it has not been analysed.

GENUS

(o) The word *gang* is used by German mineralogists to denote a metallic vein. Now, it is not often that these veins consist entirely of *ore;* in general, they contain stony matter besides. For instance, in the copper mine at Airthry, near Stirling, the copper ore is merely a narrow stripe in the middle of the vein, and the rest of it is filled up with sulphat of barytes. We use the word *gangue* (as the French do), to denote, not the *metallic* vein, but the *stony* matter which accompanies the ore in the vein. The gangue of the copper ore at Airthry is sulphat of barytes.

Order I. Bismuth? (margin)

GENUS IV. SALTS OF ANTIMONY.

SPECIES 1. Muriat of antimony*.

This ore, which has been found in Bohemia, is sometimes in quadrangular tables; fometimes in acicular cryftals grouped like zeolites; and fometimes in prifms.

253 G. IV. Salts. Muriat of antimony. * Kirw. ii. 251.

Colour pale yellowifh or greyifh white. Luftre 2 to 1, nearly metallic. Tranfparency 2. Texture foliated. Melts eafily by the flame of a candle, and emits a white vapour.†. Before the blow pipe decrepitates; when powdered, and juft ready to melt, it evaporates, and leaves a white powder around. Between two pieces of coal it is reducible to a metallic ftate.

† Pavs, Jour. de Min. N° xxxi. 669.

ORDER XI. ORES OF BISMUTH*.

* Pott, Obs. Chym. 134.—Geoffroy, Mem. Par. 1753, p. 296.

Bismuth is employed in the manufacture of pewter, of printers types, in foldering; and perhaps alfo its property of rendering other metals more fufible, might make it ufeful in anatomical injections. The quantity confumed in commerce is not great.

It has been found only in the primitive mountains, and is by no means common. When unaccompanied by any other metal, it does not form veins, but kidney-form maffes. It often accompanies cobalt. Its gangue is commonly quartz. Its ores are not very abundant. They have been found chiefly in Sweden, Norway, Tranfylvania, Germany, France, and England

254 G. I. Alloys. Native bifmuth.

GENUS I. ALLOYS OF BISMUTH.

SPECIES 1. Native bifmuth*.

* Kirw. ii 264.

This mineral, which is found at Schneeberg, Johangeorgenftadt, &c. in Germany, has commonly the form of fmall plates lying above one another. Sometimes it is cryftallized in four-fided tables, or indiftinct cubes.

Colour white with a fhade of red; furface often tarnifhed red, yellow, or purple. Luftre metallic, 3 to 2. Opaque. Texture foliated or ftriated. Hardnefs 6. Sp. gr. 9.022† to 9.57‡. Exceedingly fufible. Before the blow-pipe gives a filvery white bead, and at laft evaporates in a yellowifh white fmoke, which is depofited on the charcoal.

† Briffon. ‡ Kirwan.

It is generally accompanied by cobalt, and fometimes contains arfenic.

255 G. II. Sulphurets. Common fulphuret of bifmuth.

GENUS II. SULPHURETS OF BISMUTH.

SPECIES 1. Common fulphuret of bifmuth*.

* Kirw. ii. 266.—Sage, Mem. Par. 1782, 307.

This ore, which is found in Sweden, Saxony, and Bohemia, occurs fometimes in amorphous maffes, and fometimes in needleform cryftals.

Colour commonly bluifh grey, fometimes white; furface often tarnifhed yellow, red, and purple. Powder black and fhining. Luftre metallic, 2 to 3. Streak obfcurely metallic. Texture foliated. Hardnefs 5. Brittle. Sp gr. 6.131† to 6.4672‡. When held to the flame of a candle, it melts with a blue flame and fulphureous fmell. Before the blow-pipe emits a reddifh yellow fmoke, which adheres to the charcoal. This powder becomes white when it cools, and refumes its former colour when the flame is directed upon it*.

† Kirwan.

* Gillet, Jour. de Min. N° xxii. 58.

This ore, according to Sage, contains 60 bifmuth, And, according to La Peroufe, it holds 36 fulphur.

A fpecimen, analyfed by Klaproth, contained

95 bifmuth,

5 fulphur.

100†

† Beiträge, i. 256.

It is commonly accompanied by quartz, afbeftos, or fpairy iron ore.

256 G. III. Oxyds. Yellow oxyd of bifmuth.

GENUS III. OXYDS OF BISMUTH.

SPECIES 1. Yellow oxyd of bifmuth‡.

Bifmuth ochre.

‡ Kirw. ii. 265.

This ore generally accompanies the two fpecies already defcribed. It is found in two ftates; either of an earthy confiftence, or cryftallized in cubes or quadrangular plates.

Colour ufually greenifh yellow, fometimes grey. Soluble in nitrous acid without effervefcence, and may in a great meafure be precipitated by the effufion of water.

ORDER XII. ORES OF ARSENIC.

Arsenic is ufed as an alloy for feveral other metals, efpecially copper. It is fometimes employed to facilitate the fufion of glafs, or to render it opaque, in order to form an enamel. Preparations of arfenic are employed as paints; and, like moft other violent poifons, it has been introduced into medicine.

This metal is fcattered in great abundance over the mineral kingdom, accompanying almoft every other metal, and forming alfo fometimes peculiar veins of its own. Of courfe it occurs in almoft every fpecies of mountain, and is accompanied by a variety of gangues.

257 G. I. Alloys. Native arfenic.

GENUS I. ALLOYS OF ARSENIC.

SPECIES 1. Native arfenic†.

† Kirw. ii. 255.

This mineral is found in different parts of Germany. It occurs generally in maffes of various fhapes, kidney-form, botryoidal, &c.

Colour that of fteel. Its furface quickly becomes tarnifhed by expofure to the air. Luftre metallic (when frefh), 3 to 2. Streak bluifh grey, metallic, and bright. Powder dull and black. Texture compact. Hardnefs 7 to 8. Brittle. Sp. gr. 5.67† to 5.7249‡. Gives an arfenical fmell when ftruck. Before the blow-pipe emits a white fmoke, diffufes a garlic fmell, burns with a blue flame, gradually evaporates, depofiting a white powder.

† Kirwan. ‡ Briffon.

It is always alloyed with fome iron §, and often contains filver, and fometimes gold.

§ De Born. Catal. of M. Raab, ii. 494.

258 G. II. Sulphurets. Orpiment.

GENUS II. SULPHURETS OF ARSENIC.

SPECIES 1. Orpiment (γ).

Auripigmentum.

This ore, which is found in Hungary, Wallachia, Georgia, and Turkey in Afia, is either maffive or cryftallized. The cryftals are confufed, and their figure cannot be eafily determined; fome of them appear octohedrons, and others minute four-fided prifms.

Its colour is yellow. Streak orange yellow. Luftre waxy, 2 to 3. Tranfparency from 0 to 2. Texture foliated. Hardnefs 4 to 8. Sp. gr. from 3.048* to 3.521‡. Effervefces with hot nitric acid. Burns with a

* Kirwan. ‡ Gellert.

(γ) Kirw. II. 262.—Alberti de Auripigmento.—Scopoli in 4to Hift. Naturali, p. 59.—Berg. II. 297.

Ores of Arsenic. a bluish white flame. Before the blow-pipe melts, smokes, and evaporates, leaving only a little earth and some traces of iron.

Composed of 80 sulphur,
20 arsenic.

100

259 Realgar. SPECIES 2. Realgar*.

This mineral is found in Sicily, about Mount Vesuvius, in Hungary, Transylvania, and various parts of Germany. It is either massive or crystallized. The primitive form of the crystals is, according to Romé de Lisle, a four-sided rhomboidal prism, terminated by four-sided pyramids, the sides of which are rhombs †. It commonly appears in 4, 6, 8, 10, or 12 sided prisms, terminated by four-sided summits ‡.

Colour red. Streak yellowish red. Powder scarlet. Lustre 3 to 2. Transparency from 2 to 3; sometimes c. Hardness 5 to 6. Sp. gr. 3.3384§. It is an electric *per se*, and becomes negatively electric by friction ||. Nitric acid deprives it of its colour. Before the blow pipe it melts easily, burns with a blue flame and garlic smell, and soon evaporates.

Composed of 20 sulphur,
80 arsenic.

100

* Kirw. ii. 261.—Berg. ii. 297.

† Cryst. iii. 31.

‡ Ibid.

§ Brisson.

|| Hauy, Jour. de Min. No xxxii. 612.

260 G. III. Oxyds. White oxyd of arsenic. GENUS III. OXYDS OF ARSENIC.

SPECIES 1. White oxyd of arsenic*.

Native calx of arsenic.

This ore is found in various parts of Germany, Hungary, &c. either in powder, or massive, or crystallized in prismatic needles.

Colour white or grey, often with a tint of red, yellow, green, or black. Lustre common, 1 to 2. Transparency 1 to 0; when crystallized, 2. Texture earthy. Hardness 6. Brittle. Sp. gr. 3.7†. Soluble in hot diluted nitric acid without effervescence. Soluble at 60° Fahrenheit in 80 times its weight of water. Before the blow-pipe sublimes, but does not inflame. Tinges borax yellow.

* Kirw. ii. 258—Berg. ii. 285.

† Kirwan.

ORDER XIII. COBALT ORES.

COBALT is employed to tinge glass of a blue colour, and is useful in painting upon porcelain.

Cobalt ores are found almost exclusively in the stratified mountains, except one species, sulphuret of cobalt, which affects the primitive mountains. They are not very abundant; and for that reason cobalt is more valuable than many of the other metals which have been already treated of. They are commonly accompanied by nickel, bismuth, or iron. They are most abundant in Germany, Sweden, Norway, and Hungary; they have been found also in Britain and France, but not in any great quantity.

261 G. I. Alloys. Cobalt alloyed with arsenic. GENUS I. ALLOYS OF COBALT.

SPECIES 1. Cobalt alloyed with arsenic†.

Dull grey cobalt ore.

This ore, which occurs in different parts of Germany, is either amorphous or crystallized. The forms of its crystals are the cube; sometimes the cube with its angles, or edges, or both wanting; and the octohedron ‡.

† Kirw. ii.

‡ Romé de Lisle, iii. 3.

Its colour, when fresh broken, is whitish or bluish grey, sometimes with a shade of red; when exposed to the air it soon becomes tarnished. Streak bluish grey and metallic. Lustre scarcely metallic, 0 to 1. Texture compact. Hardness 10. Difficultly frangible. Sp. gr. when amorphous, 5.309 to 5.571§; when crystallized 7.7207†. When struck it gives out an arsenical smell. Before the blow-pipe it gives out an arsenical vapour, becomes magnetic, and melts easily, unless it contains a great quantity of iron. Tinges borax dark blue, and a small metallic bead is obtained.

§ Kirw. ii. 270.

† Hauy, Jour. de Min. No xxxii. 588.

A specimen of this ore from Cornwall, examined by Mr Klaproth, contained 20 cobalt,
24 iron,
33 arsenic,

77

with some bismuth and stony matter *.

* Klaproth's Cornwall, p 61.

Another specimen from Tunaberg, according to the analysis of the same chemist, contained
55.5 arsenic,
44.0 cobalt,
.5 sulphur.

100†

† Beitrage, ii. 307.

262 G. II. Sulphurets. White cobalt ore. GENUS II. SULPHURETS OF COBALT.

SPECIES 1. White cobalt ore ‡.

Sulphuret of cobalt, arsenic, and iron.

The descriptions which different mineralogists have given of this ore are so various, that it is impossible not to suppose that distinct substances have been confounded together.

It occurs either in masses, or crystallized in cubes, dodecahedrons, octohedrons, and icosahedrons.

Colour tin white, sometimes tarnished reddish or yellowish. Powder steel grey. Lustre partly metallic, and from 2 to 4; partly 0 or 1. Texture foliated. Hardness 8 to 9. Sp. gr. from 6.284† to 6.4509‡. Before the blow-pipe generally gives out an arsenical vapour, and does not melt.

‡ Kirw. ii. 273.—Sage, Jour de Phys. xxx. 53.

† Kirwan.

‡ Hauy.

The analyses that have been given of this ore are very various. Sometimes it has been found to contain no arsenic nor iron, and sometimes to contain both. A specimen from Tunaberg in Sweden, which ought to belong to this species, was analysed by Tassaert, and found to consist of 49 arsenic,
36.6 cobalt,
5.6 iron,
6.5 sulphur.

97.8†

† Ann. de Chim. xxvi.

Klaproth found a specimen of the same ore to contain 55.5 arsenic,
44.0 cobalt,
0.5 sulphur.

100.0‡

263 G. III. Oxyds. Black cobalt ore or ochre. GENUS III. OXYDS OF COBALT.

SPECIES 1. Black cobalt ore or ochre§.

This ore, which occurs in different parts of Germany, is either in the form of a powder, or indurated.

Colour black, often with a shade of blue, grey, brown, or green. Lustre 0 to 1. Streak brighter. Hardness (of the indurated) from 4 to 8. Sp. gr. 3 to 4. Soluble in muriatic acid. Tinges borax blue.

Ores of Nickel.

264 Brown cobalt ore. * Kirw. ii. 270.

SPECIES 2. Brown cobalt ore*.

Colour greyish or dark leather brown. Streak brighter, unctuous. Communicates a pale blue tinge in fusion.

205 Yellow cobalt ore. † Ibid.

SPECIES 3. Yellow cobalt ore †.

Colour yellow. Dull and earthy. Hardness 4 to 5. Texture earthy. Streak brighter, unctuous. Gives a weak blue tinge.

206 G. IV. Salts. Arseniat of cobalt. ‡ Id. 278.

GENUS IV. SALTS OF COBALT.

SPECIES 1. Arseniat of cobalt ‡.

Red cobalt ore.

This species, like most other ores of cobalt, has neither been accurately described nor analysed.

It is found in masses of various shapes, and crystallized in quadrangular tables or acicular prisms.

Colour red. Lustre from 2 to 3, sometimes 0. Transparency 0 to 2. Hardness 5 to 7. Brittle. Before the blow pipe becomes blackish grey. Diffuses a weak arsenical smell. Tinges borax blue.

ORDER XIV. ORES OF NICKEL.

HITHERTO nickel has been found in too small quantities to be applied to any use; of course there are, properly speaking, no mines of nickel. It occurs only (as far as is yet known) in the secondary mountains, and it commonly accompanies cobalt. It has been found in different parts of Germany, in Sweden, Siberia, Spain, France, and Britain.

267 G. I. Sulphurets. Sulphuret of nickel with arsenic and iron. * Ibid. 286.

GENUS I. SULPHURETS OF NICKEL.

SPECIES 1. Sulphuret of nickel with arsenic and iron.

*Kupfer nickel**.

This, which is the most common ore of nickel, occurs either massive or disseminated, but never crystallized.

Colour often that of copper, sometimes yellowish white or grey. Recent fracture often silver white. Lustre metallic, 2 to 3. Texture compact. Hardness 8. Sp. gr. 6.6086 to 6.6481 ‡. Soluble in nitric and nitro-muriatic acids. Solution green. Before the blow-pipe exhales an arsenical smoke, and melts into a bead which darkens by exposure to the air.

‡ Brisson.

It is composed of various proportions of nickel, arsenic, iron, cobalt, sulphur; often contains bismuth, and sometimes silver and copper.

268 G. II. Oxyds. Nickel ochre. * Kirw. ii. 284.

GENUS II. OXYDS OF NICKEL.

SPECIES 1. Nickel ochre*.

This mineral occurs either in the form of a powder, or indurated, and then is either amorphous, or crystallized in acicular form crystals. The powder is generally found on the surface of other nickel ores.

Colour different shades of green. Lustre 1 to 0. Texture earthy. Sp. gr. considerable. Slowly dissolves in acids: solution green. Before the blow-pipe does not melt; but gives a yellowish or reddish brown tinge to borax.

This ore often contains sulphat of nickel, which is soluble in water. The solution, when evaporated, gives oblong rhomboidal crystals, from which alkalies precipitate a greyish green oxyd. This oxyd is soluble by acids and by ammonia. The acid solution is green; the alkaline blue.

Metallic Ores.

269 G. III. Salts. Arseniat of nickel. † Kirw. ii. 285.

GENUS III. SALTS OF NICKEL.

SPECIES 1. Arseniat of nickel †.

This ore, which was lately discovered at Regendorff by Mr Gmelin, is found in shapeless masses, and is often mixed with plates of sulphat of barytes.

Colour pale grey, here and there mixed with pale green. Streak white. Lustre 0. Texture compact. Hardness 7. Difficultly frangible. Sp. gr. considerable. Adheres slightly to the tongue, and gives an earthy smell when breathed on. Soluble in hot nitric and muriatic acids: solution green.

Contains some cobalt and alumina.

ORDER XV. ORES OF MANGANESE (q).

HITHERTO manganese, in its metallic state, has scarcely been put to any use; but under the form of an oxyd it has become of great importance. The oxyd of manganese has the property of rendering colourless a variety of bodies which injure the transparency of glass; and it has been long used in glass manufactories for this purpose under the name of *glass soap*. By means of the same oxyd, oxy-muriatic acid is prepared, which has rendered manganese of great importance in bleaching. Not to mention the utility of manganese to the chemist, the property which it has of facilitating the oxydation of other metals, and of rendering iron more fusible—will probably make it, in no very remote period, of very considerable importance in numerous manufactories.

Ores of manganese occur often in strata, both in the primitive and secondary mountains; scarcely ever, however, we believe, in those mountains which are considered as the most ancient of all. They are very common, having been found abundantly in Germany, France, Spain, Britain, Sweden, Norway, Siberia, and other countries.

270 G. I. Oxyds.

GENUS I. OXYDS OF MANGANESE.

Hitherto manganese has only been found in the state of oxyd. La Perouse, indeed, suspected that he had found it in a metallic state: but probably there was some mistake or other in his observations.

271 Oxyd of manganese combined with barytes.

SPECIES 1. Oxyd of manganese combined with barytes.

This species, which exists in great abundance in Romaneche near the river Soane in France, is found massive, forming a stratum in some places more than 12 feet thick.

Colour greyish black or brownish black, of great intensity. Lustre, external, 0; internal, metallic, 1. Soon tarnishes by exposure to the air, and then becomes intensely black. Texture granular. Fracture uneven; sometimes conchoidal. Often porous. Hardness 11. Difficultly frangible. Sp gr. from 3.950 to 4.10. Absorbs water. When taken out of water after a minute's immersion, it has a strong argillaceous smell. Conducts electricity nearly as well as if it were in a metallic state ‡. Infusible by the blow-pipe. Tinges soda red; the colour disappears before the blue cone of flame, and is reproduced by the action of the yellow flame.

From

(q) *Pott. Miscelan. Berolens*, VI. 40.—*Margraff, Mem. Berlin*, 1773, p. 3.—*La Perouse, Jour. de Phys.* XVI. 156. and XV. 67. and XXVIII. 68.—*Sage, Mem. Par.* 1785, 235.

Ores of Manganese.

From the analysis of Vauquelin, it appears that it is composed of

50.0	white oxyd of manganese,
33.7	oxygen,
14.7	barytes,
1.2	silica,
.4	charcoal.
100.0 ¶	

¶ *Dolomieu, Jour. de Min.* N° xix. 42.

SPECIES 2. Grey ore of manganese *.

272 Grey ore of manganese.

This ore occurs both massive and disseminated; it is also sometimes crystallized in slender four-sided prisms or needles.

Colour usually dusky steel grey; sometimes whitish grey, or reddish grey. Streak and powder black. External lustre 3 to 2; internal metallic, 2 to 1. Texture striated or foliated. Hardness 4 to 5. Brittle. Sp. gr. from 4.073 † to 4.8165 ‡. Before the blow-pipe darkens: tinges borax reddish brown.

* *Kirwan*, ii. 291. † *Vauquelin*. ‡ *Brisson*.

A specimen of oxyd of manganese from the mountains of Vosges, which probably belonged to this species, and which was analysed by Vauquelin, was composed of

82	oxyd of manganese,
7	carbonat of lime,
6	silica,
5	water.
100 §	

§ *Jour. de Min.* N° xvii. 13.

Sometimes it contains a little barytes and iron.

SPECIES 3. Black or brown ore of manganese *.

273 Black or brown ore of manganese.

This ore is found sometimes in the state of powder, and sometimes indurated in amorphous masses of various figures. Colour either black, sometimes with a shade of blue or brown; or reddish brown. Streak of the harder sorts metallic; of the others, black. Lustre 0 to 1; internal (when it is indurated), metallic. Texture compact. Hardness 5 to 7. Sp. gr. 3.7076 to 3.9039; that of the powdery sometimes only 2. Before the blow-pipe it exhibits the same phenomena as the last species.

* *Kirwan*, ii. 291.—*Wedgewood, Phil. Transf.* lxxiii. 284.

A specimen of this ore, analysed by Westrum, contained

45.00	manganese,
14.00	oxyd of iron,
11.00	silica,
7.25	alumina,
2.00	lime,
1.50	oxyd of copper,
18.00	air and water.
98.75	

274 G. II. Salts.

GENUS II. SALTS OF MANGANESE.

SPECIES 1. Carbonat of manganese †.

Carbonat of manganese.

White ore of manganese.

This species occurs in Sweden, Norway, and Transylvania. It is either in the form of loose scales, or massive, or crystallized in needles.

† *Kirwan*, ii. 297.

Colour white, or reddish white. Texture either radiated or scaly. Lustre of the scaly 2. Transparency 1 to 2. Hardness of the massive 6 to 9. Sp. gr. 2.794. Effervesces with mineral acids. Heated to redness, blackens. Tinges borax violet.

Metallic Ores.

SPECIES 2. Red ore of manganese †.

Carbonat of manganese and iron.

275 Red ore of manganese.

This species has been found in Piedmont and in the Pyrenees. It is sometimes in powder, sometimes massive, sometimes crystallized in rhomboidal prisms or needles.

Colour pale rosy red, mixed with white. Powder nearly white. Lustre 0. Transparency 1. Hardness 8. Sp. gr. 3.233. Effervesces with nitric and muriatic acids. When heated to redness becomes reddish brown. Tinges borax red.

† *Kirwan*, ii. 297.—*Napion, Mem. Turin*, iv. 303.

A specimen, analysed by Ruprecht, contained

55	silica,
35	oxyd of manganese,
7	oxyd of iron,
1.5	alumina.
98.5 §	

§ *Jour. de Phys.* xxxi. 22.

ORDER XVI. ORES OF TUNGSTEN.

As no easy method has hitherto been discovered of reducing tungsten to a metallic state, we need not be surprised that it has been applied to no use. Ores of tungsten are by no means common. They have hitherto been found only in the primitive mountains. Their gangue is commonly quartz. They very often accompany tin ores.

276 G. I. Oxyds. Wolfram.

GENUS I. OXYDS OF TUNGSTEN.

SPECIES 1. Wolfram (R).

Oxyds of tungsten, iron, and *manganese—Tungstat of iron* and *manganese*.

This species is found in different parts of Germany, in Sweden, Britain, France, and Spain; and is almost constantly accompanied by ores of tin. It occurs both massive and crystallized. The primitive form of its crystals, according to the observations of Mr Hauy, is a rectangular parallelopiped ‡, whose length is 8.66, whose breadth is 5, and thickness 4.33 *. It is not common, however, to find crystals of this perfect form; in many cases, the angles, and sometimes the edges, of the crystal are wanting ‡; owing, as Mr Hauy has shewn, to the superposition of plates, whose edges or angles decrease according to a certain law †.

‡ Fig. 42. * *Jour. de Min.* N° xix. 8. ‡ Fig. 43. † *Jour de Min.* N° xix. 8.

Colour brown or brownish black. Streak reddish brown. Powder stains paper with the same colour. Lustre external, 2; internal, 2 to 3; nearly metallic. Texture foliated. Easily separated into plates by percussion. Hardness 6 to 8. Sp. gr. from 7.006 * to 7.333 †. Moderately electric by communication. Not magnetic. Infusible by the blow-pipe. Forms with borax a greenish globule, and with microcosmic salt a transparent globule of a deep red ¶.

* *Kirwan*. † *Hauy*. ¶ *Vauquelin, Jour de Min*, N° xix. 11.

The specimen of this ore examined by Messrs d'Elhuyarts, was composed of

65	oxyd of tungsten,
22	oxyd of manganese,
13	oxyd of iron.
100	

Another

(R) *Kirw.* II. 316.—*De Luyart, Mem. Thoulouse*, II. 141.—*Gmelin, Crell's Jour.* English transf. III. 127, 205, and 293.—*La Perouse, Jour. de Min.* N° IV. p. 23.

Ores of Molybdenum.

Another specimen from Pays le Mines in France, analysed by Vauquelin and Hecht, contained

67.00 oxyd of tungsten,
18.00 black oxyd of iron,
6.25 black oxyd of manganese,
1.50 silica,
7.25 oxyd of the iron and manganese.

100.00 §

§ Vauquelin, Jour. de Min. N° xix 11.

Genus II. salts of tungsten.

species 1. Tungstat of lime (s).

Tungsten.

277 G. II Salts. Tungstat of lime. This ore, which is now exceedingly scarce, has hitherto been found only in Sweden and Germany. It is either massive or crystallized; and, according to Hauy, the primitive form of its crystals is the octohedron †.

† Jour de Min. N° xxxiii. 657.

Colour yellowish white or grey. Lustre 3 to 2. Transparency 2 to 3. Texture foliated. Hardness 6 to 9. Sp. gr, 5.8 to 60665. Becomes yellow when digested with nitric or muriatic acids. Infusible by the blow-pipe. With borax forms a colourless glass, unless the borax exceed, and then it is brown. With microcosmic salt it forms a blue glass, which loses its colour by the yellow flame, but recovers it in the blue flame ‡.

‡ Scheele and Bergman.

It is composed of about 70 oxyd of tungsten,
30 lime,

100

with a little silica and iron §.

§ Scheele.

species 2. Brown tungstat.

278 Brown tungstat. This ore is found in Cornwal, and is either massive or composed of small crystalline grains.

Colour grey, variegated with yellow and brown. Lustre 2, waxy. Hardness 6 to 7. Sp. gr. 5.57. Its powder becomes yellow when digested in aqua regia.

According to Klaproth, it is composed of

88 oxyd of tungsten,
11.5 lime.

99.5

Order XVII. ORES OF MOLYBDENUM.

If ever molybdenum be found in abundance, it will probably be useful in dyeing and painting. At present it is very scarce, having only been found in Sweden, Germany, Carniola, and among the Alpes. Like tin and tungsten, it affects the primitive mountains.

Genus I. sulphuret of molybdenum.

species 1. Common sulphuret (t).

Molybdena.

279 G. I. Sulphuret. Common sulphuret. This ore, which is the only species of molybdenum ore at present known, is found commonly massive; sometimes, however, it is crystallized in hexahedral tables.

Colour light lead grey; sometimes with a shade of red. Streak bluish grey, metallic. Powder bluish. Lustre metallic, 3 to 2. Texture foliated. Lamellæ slightly flexible. Hardness 4. Sp. gr. 4.569 * to 4.7385 †. Feels greasy; stains the fingers. Marks bluish black. A piece of resin rubbed with this mineral becomes positively electric ‡. Insoluble in sulphuric and muriatic acids; but in a boiling heat colours them green. Effervesces with warm nitric acid, leaving a grey oxyd undissolved. Before the blow-pipe, on a silver spoon, emits a white smoke, which condenses into a white powder, which becomes blue in the internal, and loses its colour in the external, flame. Scarcely affected by borax or microcosmic salt. Effervesces with soda, and gives it a reddish pearl colour.

* Kirwan. † Brisson. ‡ Hauy, Jour. de Min. N° xix. 70.

Composed of about 60 molybdenum,
40 sulphur.

100 *

* Klaproth.

Order XVIII. ORES OF URANIUM.

Uranium has hitherto been found only in Germany, and has not been applied to any use. The only two mines where it has occurred are in the primitive mountains.

Genus I. oxyds of uranium.

species 1. Sulphuret of uranium †.

Pechblende.

280 G I. Oxyds. Sulphuret of uranium. This ore, which has been found at Johanngeorgenstadt in Saxony, and Joachimsthal in Bohemia, is either massive or stratified with other minerals.

† Kirwan, ii. 305.

Colour black or brownish black; sometimes with a shade of grey or blue. Streak darker. Powder opaque and black. Lustre semimetallic, from 3 to 1. Fracture conchoidal. Hardness 7 to 8. Very brittle. Sp. gr. from 6.3785 ‡ to 7.5, and even higher §. Imperfectly soluble in sulphuric and muriatic acids; perfectly in nitric acid and aqua regia. Solution wine yellow. Infusible with alkalies in a crucible; infusible by the blow-pipe *per se*. With borax and soda forms a grey opaque slag; with microcosmic salt, a green glass.

‡ Morveau, Jour. de Min. N° xxxii 610. § Klaproth, Beiträge, ii. 197.

Composed of oxyd of uranium and sulphur, and mixed with iron and silica, and sometimes lead.

A specimen of this ore from Joachimsthal, analysed lately by Klaproth, contained

86.5 uranium,
6.0 sulphuret of lead,
5.0 silica,
2.5 oxyd of iron,

100.0 *

* Beiträge, ii. 221.

species 2. Yellow oxyd of uranium ‡.

Uranitic ochre.

281 Yellow oxyd of uranium. This ore is generally found on the surface of the last species at Johanngeorgenstadt, and is either massive or in powder.

‡ Kirwan, ii. 303.

Colour yellow, red, or brown. Streak of the yellow sorts yellow; of the red, orange yellow. Lustre 0. Slightly stains the fingers. Feels meagre. Texture earthy. Hardness 3 to 4. Sp. gr. 3.2438 ‖. Infusible by the blow-pipe; but in a strong heat becomes brownish grey.

‖ Hauy, Jour. de Min. ibid.

Composed of oxyd of uranium and oxyd of iron.

Genus

(s) *Kirw.* II. 314.—*Scheele's Works* (French translation), II. 81.—*Bergman, ibid.* p. 94.—*Crell, Chem. Annalen.* 1784. 2 *Band* 195.

(t) *Kirw.* II. 322.—*Scheele's Works* (French translation), I. 236.—*Pelletier, Jour. de Phys.* XXVII. 434.—*Ilsimann, ibid.* XXXIII. 292.—*Sage, ibid.* 389.—*Klaproth* and *Modeer, Ann. de Chim.* III. 120.

Ores of Titanium.

282
G. II. Salts Carbonat of uranium

GENUS II. SALTS OF URANIUM.

SPECIES 1. Carbonat of uranium ¶.

This substance is also found at Johanngeorgenstadt, and near Eibenstock and Rheinbreidenbach §. It is sometimes amorphous, but more commonly crystallized. Its crystals are square plates, octohedrons, and six sided prisms.

¶ *Kirwan*, ii. 304.
§ *Gmelin*.

Colour green; sometimes nearly white; sometimes, though rarely, yellow. Streak greenish white. Lustre 3 to 2; internal, 2; sometimes pearly; sometimes nearly metallic. Transparency 2 to 3. Texture foliated. Hardness 5 to 6. Brittle. Soluble in nitric acid without effervescence. Infusible by alkalies.

Composed of carbonat of uranium, with some oxyd of copper. When its colour is yellow it contains no copper.

ORDER XIX. ORES OF TITANIUM.

TITANIUM has been known for so short a time, and its properties are yet so imperfectly ascertained, that many of its uses must remain to be discovered. Its oxyd, as we learn from Mr Darcet, has been employed in painting on porcelain *. Hitherto it has been found only in the primitive mountains, the Crapacks †, the Alpes (u), and the Pyrenees ‡. It has been found also in Brittany ‖ and in Cornwal.

* *Jour. de Min.* N° xv. 27.
† *Ibid*, N° xii. 51.
‡ *Jour. de Min.* N° xxxii. 614.
‖ *Ibid.*

GENUS I. OXYDS OF TITANIUM.

SPECIES 1. Red oxyd of Titanium.

Red shorl—Sagenite.

283
G. I. Oxyds Red oxyd of titanium.

This ore has been found in Hungary, the Pyrenees, the Alpes, and in Brittany in France. It is generally crystallized. The primitive form of its crystals, according to the observations of Mr Hauy, is a rectangular prism, whose base is a square; and the form of its molecules is a triangular prism, whose base is a right angled isosceles triangle, and the height is to any of the sides of the base about the right angle as $\sqrt{12}$ to $\sqrt{5}$, or nearly as 3 : 2 ¶. Sometimes the crystals of titanium are six sided, and sometimes four-sided, prisms, and often they are implicated together ‡.

¶ *Jour. de Min.* N° xv. 28. and xxxii. 615.
‡ Fig. 44.

Colour red or brownish red. Powder brick or orange red. Lustre 3. Transparency commonly 0; sometimes 1. Texture foliated. Hardness 9. Brittle. Sp. gr. from 4.18 * to 4.2469 †. Not affected by the mineral acids. When fused with carbonat of potass, and diluted with water, a white powder precipitates, heavier than the titanium employed. Before the blow-pipe it does not melt, but becomes opaque and brown. With microcosmic salt it forms a globule of glass, which appears black; but its fragments are violet. With borax it forms a deep yellow glass, with a tint of brown. With soda it divides and mixes, but does not form a transparent glass.

* *Klaproth.*
† *Vauquelin* and *Hecht.*

When pure, it is composed entirely of oxyd of titanium.

284
Menachanite.

SPECIES 2. Menachanite (x).

Oxyd of titanium combined with iron.

This substance has been found abundantly in the valley of Menachan in Cornwal; and hence was called menachanite by Mr Gregor, the discoverer of it. It is in small grains, like gunpowder, of no determinate shape, and mixed with a fine grey sand. Colour black. Easily pulverized. Powder attracted by the magnet. Sp. gr. 4.427. Does not detonate with nitre. With two parts of fixed alkali it melts into an olive coloured mass, from which nitric acid precipitates a white powder. The mineral acids only extract from it a little iron. Diluted sulphuric acid, mixed with the powder, in such a proportion that the mass is not too liquid, and then evaporated to dryness, produces a blue coloured mass. Before the blow-pipe does not decrepitate nor melt. It tinges microcosmic salt green; but the colour becomes brown on cooling: yet microcosmic salt does not dissolve it. Soluble in borax, and alters its colour in the same manner.

Metallic Ores.

According to the analysis of Mr Gregor, it is composed of

46	oxyd of iron,
45	oxyd of titanium.
91	with some silica and manganese †.

† *Mr Gregor, Jour. de Phys.* xxxix. 2. 152.

According to Mr Klaproth's analysis, it is composed of

51.00	oxyd of iron,
45.25	oxyd of titanium,
3.50	silica,
.25	oxyd of manganese.
100.00 ‡	

‡ *Beiträge*, i. 231.

A mineral, nearly of the same nature with the one just described, has been found in Bavaria. Its specific gravity, however, is only 3.7. According to the analysis of Vauquelin and Hecht, it is composed of

49	oxyd of titanium,
35	iron,
2	manganese,
14	oxygen combined with the iron and manganese
100 §	

§ *Jour. de Min.* No xix. 57.

285
Calcareo-siliceous ore of titanium.

SPECIES 3. Calcareo siliceous ore of titanium.

Oxyd of titanium combined with lime and silica—Titanite †.

This ore has hitherto been found only near Passau. It was discovered by Professor Hunger. It is sometimes massive, but more commonly crystallized in four sided prisms, not longer than one fourth of an inch.

† *Kirwan*, ii. 331.

Colour reddish, yellowish, or blackish brown; sometimes whitish grey. Powder whitish grey. Lustre waxy or nearly metallic, 2 to 3. Transparency from 0 to 2. Texture foliated. Hardness 9 or more. Brittle. Sp. gr. 3.510. Muriatic acid, by repeated digestion, dissolves one-third of it. Ammonia precipitates from this solution a clammy yellowish substance. Infusible by the blow-pipe, and also in a clay crucible; but in charcoal is converted into a black opaque porous slag.

According to the analysis of Klaproth, it is composed of

33	oxyd of titanium,
35	silica,
33	lime.
101	

(u) *Dolomieu, Jour. de Min.* N° XLII. 431. and *Saussure, Voyages*, N° 1894.

(x) *Kirw.* II. 326.—*Gregor, Jour. de Phys.* XXXIX. 72. and 152.—*Schmeiss*. *Crell's Annals* (English translation), III. 252.

Ores of Tellurium.

ORDER XX. ORES OF TELLURIUM.

HITHERTO tellurium has only been found in Transylvania. It occurs in three different mines; that of Fatzbay, Offenbanya, and Nagyag, which are considered as gold mines, because they contain less or more of that metal. Its gangue is commonly quartz.

256 G. I. Alloys. White gold ore of Fatzbay.

GENUS I. ALLOYS OF TELLURIUM.

SPECIES 1. White gold ore of Fatzbay.

Alloy of tellurium and iron, with some gold.

This species is generally massive. Its colour is between tin white and lead grey. Lustre considerable, metallic. Texture granular *.

According to Klaproth's analysis, it is composed of

72.0 iron,
25.5 tellurium,
2.5 gold.

100.0 †

* *Ann. de Chim.* xxv. 327.

† *Ibid.* 280.

257 Graphic golden ore of Offenbanya.

SPECIES 2. Graphic golden ore of Offenbanya.

Tellurium alloyed with gold and silver.

This ore is composed of flat prismatic crystals; the arrangement of which has some resemblance to Turkish letters. Hence the name of the ore.

Colour tin white, with a tinge of brass yellow ‡. Lustre metallic, 3. Hardness 4 to 5. Brittle. Sp. gr. 5.723. Before the blow-pipe decrepitates, and melts like lead. Burns with a lively brown flame and disagreeable smell, and at last vanishes in a white smoke, leaving only a whitish earth ‖.

According to Klaproth's analysis, it is composed of

60 tellurium,
30 gold,
10 silver,

100 §

‡ *Ann de Chim* xxv. 328.

‖ *De Born, Kirwan's Min.* ii. 101.

The yellow gold ore of Nagyag would belong to this species were it not that it contains lead. Its composition, according to Klaproth's analysis, is as follows:

45.0 tellurium,
27.0 gold,
19.5 lead,
8.5 silver,

100.0 and an atom of sulphur *

§ *Ann. de Chim.* xxv. 280.

* *Ibid.*

288 Grey foliated gold ore of Nagyag.

SPECIES 3. Grey foliated gold ore of Nagyag.

This ore is found in plates, of different degrees of thickness, adhering to one another, but easily separable: these are sometimes hexahedral, and often accumulated so as to leave cells between them.

Colour deep lead grey, passing to iron black, spotted. Lustre metallic, moderate. Texture foliated; leaves slightly flexible †. Hardness 6. Sp. gr. 8.919. Stains the fingers. Soluble in acids with effervescence ‡.

According to Klaproth, it is composed of

50.0 lead,
33.0 tellurium,
8.5 gold,
7.5 sulphur,
1.0 silver and copper.

100.0 §

† *Klaproth, Ann. de Chim.* xxv. 329.

‡ *De Born, Kirwan's Min.* ii. 99.

Metallic

ORDER XXI. ORES OF CHROMUM.

CHROMUM has hitherto been found in too small quantities for its extensive application to the arts. Whenever it becomes plentiful, its properties will render it of great importance both to the dyer and painter. Nature has used it to colour some of her most beautiful mineral productions: And can art copy after a better model? Hitherto it has been found only in two places, near Ekaterinbourg in Siberia, and in the department of the Var in France. In the first of these places, and probably also in the second, its gangue is quartz.

GENUS I. SALTS OF CHROMUM.

SPECIES 1. Chromat of lead. 289 G. I. Salts. Chromat of lead.

Red lead ore of Siberia.

This singular mineral, which has now become scarce, is found in the gold mines of Beresof near Ekaterimbourg in Siberia, crystallized in four-sided prisms, sometimes terminated by four-sided pyramids, sometimes not.

Colour red, with a shade of yellow. Streak and powder a beautiful orange yellow. Lustre from 2 to 3. Transparency 2 to 3. Structure foliated. Texture compact. Fracture uneven. Hardness 5 to 4. Sp. gr. 6.0269 † to 5.75 ‡. Does not effervesce with acids. Before the blow-pipe decrepitates; some lead is reduced, and the mineral is converted to a black slag, which tinges borax green.

According to the analysis of Vauquelin, it is composed of

65.12 oxyd of lead,
34.88 chromic acid.

100.00 ‖.

† *Brisson.*
‡ *Bindheim.*
‖ *Jour. de Min.* N° xxxiv. 760.

SPECIES 2. Chromat of iron.

290 Chromat of iron.

This mineral, which has been found only near Gassin in the department of Var in France, is in irregular masses.

Colour brown, not unlike that of brown blende. Lustre metallic. Hardness moderate. Sp. gr. 4.0326. Melts with difficulty before the blow-pipe; to borax it communicates a dirty green. Insoluble in nitric acid. Melted with potass, and dissolved in water, the solution assumes a beautiful orange yellow colour.

It is composed of 63.6 chromic acid,
36.0 oxyd of iron.

99.6 †

† *Tassaert, Ann. de Chim.* xxxi. 220.

CHAP. IV. OF THE CHEMICAL ANALYSIS OF MINERALS.

291 Analysis of minerals.

THE progress which the art of analysing minerals has made within these last twenty years is truly astonishing. To separate five or six substances intimately combined together, to exhibit each of them separately, to ascertain the precise quantity of each, and even to detect the presence and the weight of substances which do not approach $\frac{1}{100}$th part of the compound, would, at no very remote period, have been considered as a hopeless, if not an impossible, task; yet this can now be done with the most rigid accuracy.

292 Begun by Margraff.

The first person who undertook the analysis of minerals was Margraff of Berlin. His attempts were indeed rude; but their importance was soon perceived by other chemists, particularly by Bergman and Scheele, whose

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whose industry and address brought the art of analysing minerals to a considerable degree of perfection.

But their methods, though they had very considerable merit, and, considering the state of the science, are wonderful proofs of the genius of the inventors, were often tedious and uncertain, and could not in all cases be applied with confidence. These defects were perceived by Mr Klaproth of Berlin, who applied himself to the analysis of minerals with a persevering industry which nothing could fatigue, and an ingenuity and accuracy which nothing could perplex. He corrected what was wrong, and supplied what was wanting, in the analytical method; invented new processes, discovered new instruments; and it is to his labours, more than to those of any other chemist, that the degree of perfection, to which the analysis of minerals has attained, is to be ascribed. Many improvements, however, were introduced by other chemists, especially by Mr Vauquelin, whose analyses in point of accuracy and ingenuity rival those of Klaproth himself.

293 Improved by Klaproth

294 And other chemists.

We shall, in this chapter, give a short description of the most perfect method of analysing minerals, as far as we are acquainted with it. We shall divide the chapter into four sections. In the first, we shall give an account of the instruments used in analyses; in the second, we shall treat of the method of analysing stones; in the third, of analysing combustibles; and in the fourth, of the analyses of ores.

Sect. I. *Of the Instruments of Analyses.*

295 Method of obtaining chemical agents pure.

I. The chemical agents, by means of which the analysis of minerals is accomplished, ought to be prepared with the greatest care, because upon their purity the exactness of the operation entirely depends. These agents are the three alkalies, both pure and combined with carbonic acid; the sulphuric, nitric, and muriatic acids; hydrosulphuret of potash and sulphurated hydrogen gas dissolved in water; prussic alkali, and a few neutral salts.

1. Potash and soda may be obtained pure, either by means of alcohol, or by the method described in the article Chemistry, n° 372. *Suppl.* These alkalies are known to be pure when their solution in pure water occasions no precipitate in lime and barytic water; when the precipitate which it produces in a solution of silver is completely dissolved by nitric acid; and, lastly, when saturated with carbonic acid it deposits no silica.

2. Ammonia is procured by distilling one part of muriat of ammonia with two parts of quicklime, and receiving the gas in a dish containing a quantity of pure water, equal in weight to the muriat employed. Its purity is known by the same tests which ascertain the purity of fixed alkalies.

3. The carbonats of potash and soda may be formed by dissolving the potash and soda of commerce in pure water, saturating the solution with carbonic acid, and crystallizing them repeatedly. When pure, these crystals effloresce in the air; and the precipitate which they occasion in solutions of barytes and of silver is completely soluble in nitric acid. Carbonat of ammonia is obtained by distilling together one part of muriat of ammonia and two parts of carbonat of lime.

4. The sulphuric acid of commerce often contains nitric acid, potash, lead, &c. It may be purified by distillation in a low cucurbite. The first portion, when it comes over, must be set aside; it contains the nitric acid. The other impurities remain behind in the cucurbite. Sulphuric acid, when pure, dissolves indigo without altering its colour, does not attack mercury while cold, and causes no precipitate in pure alkaline solutions.

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5. Nitric acid often contains both sulphuric and muriatic acids. It is easily purified by throwing into it about three parts of litharge in fine powder for every 100 parts of the acid, allowing the mixture to remain for 24 hours, shaking it occasionally, and then distilling it. The sulphuric and muriatic acids combine with the lead, and remain behind in the retort. Pure nitric acid occasions no precipitate in the solutions of barytes and silver.

6. The muriatic acid of commerce usually contains sulphuric acid, oxymuriatic acid, and oxyd of iron. It may be purified by distillation with a little muriat of soda; taking care to set aside the first portion which comes over. When pure it causes no precipitate in the solution of barytes, nor of pure alkalies, and does not attack mercury while cold.

7. Hydrosulphuret of potash is made by saturating a solution of pure potash with sulphurated hydrogen gas; and water may be saturated with sulphurated hydrogen gas in the same manner. See Chemistry, n° 857. *Suppl.*

8. The method of preparing prussic alkali, oxalic acid, and the other substances used in analyses, has been already described in the article Chemistry, *Suppl.* it is unnecessary therefore to repeat it here.

II. Before a mineral is submitted to analysis, it ought to be reduced to an impalpable powder. This is by no means an easy task when the stone is extremely hard. It ought to be raised to a bright red or white heat in a crucible, and then instantly thrown into cold water. This sudden transition makes it crack and break into pieces. If these pieces are not small enough, the operation may be repeated on each till they are reduced to the proper size. These fragments are then to be beaten to small pieces in a polished steel mortar; the cavity of which should be cylindrical, and the steel pestle should fit it exactly, in order to prevent any of the stone from escaping during the act of pounding. As soon as the stone is reduced to pretty small pieces, it ought to be put into a mortar of rock crystal or flint, and reduced to a coarse powder. This mortar should be about four inches in diameter, and rather more than an inch in depth. The pestle should be formed of the same stone with the mortar, and care should be taken to know exactly the ingredients of which this mortar is composed. Klaproth's mortar is of flint. We have given its analysis in n° 32. of this article.

296 How to reduce the mineral to powder.

When the stone has been reduced to a coarse powder, a certain quantity, whose weight is known exactly, 100 grains for instance, ought to be taken and reduced to as fine a powder as possible. This is best done by pounding small quantities of it at once, not exceeding 10 grains. The powder is as fine as possible when it feels soft, adheres together, and as it were forms a cake under the pestle. It ought then to be weighed exactly. It will almost always be found heavier after being pounded than it was before; owing to a certain quantity of the substance of the mortar which has been rubbed off during the grinding and mixed with the powder.

Analysis of Minerals. der. This additional weight must be carefully noted; and after the analysis, a portion of the ingredients of the mortar, corresponding to it, must be subtracted.

297 Chemical vessels. III. It is necessary to have a crucible of pure silver, or, what is far preferable, of platinum, capable of holding rather more than seven cubic inches of water, and provided with a cover of the same metal. There should also be ready a spatula of the same metal about four inches long.

The dishes in which the solutions, evaporations, &c. are performed, ought to be of glass or porcelain. Those of porcelain are cheaper, because they are not so apt to break. Those which Mr Vauquelin uses are of porcelain; they are sections of spheres, and are glazed both within and without, except that part of the bottom which is immediately exposed to the fire.

Sect. II. *Analysis of Stones* (y).

298 Ingredients of stones. The only substances which enter into the composition of the simple stones, as far at least as analysis has discovered, are the six earths, silica, alumina, zirconia, glucina, lime, and magnesia; and the oxyds of iron, manganese, nickel, chromum, and copper (z). Seldom more than four or five of these substances are found combined together in the same stone: we shall suppose, however, in order to prevent unnecessary repetitions, that they are all contained in the mineral which we are going to analyse.

299 Method of decomposing stones. Let 100 or 200 grains of the stone to be analysed, previously reduced to a fine powder, be mixed with three times its weight of pure potass and a little water, and exposed in the silver or platinum crucible to a strong heat. The heat should at first be applied slowly, and the matter should be constantly stirred, to prevent the potass from swelling and throwing any part out of the crucible. When the whole water is evaporated, the mixture should be kept for half an hour or three quarters in a strong red heat.

If the matter in the crucible melts completely, and appears as liquid as water, we may be certain that the stone which we are analysing consists chiefly of silica; if it remains opaque, and of the consistence of paste, the other earths are most abundant; if it remains in the form of a powder, alumina is the prevalent earth. If the matter in the crucible be of a dark or brownish red colour, it contains oxyd of iron; if it is grass green, manganese is present; if it is yellowish green, it contains chromum.

When the crucible has been taken from the fire and wiped on the outside, it is to be placed in a capsule of porcelain, and filled with water. This water is to be renewed from time to time till all the matter is detached from the crucible. The water dissolves a part of the combination of the alkali with the silica and alumina of the stone, and if a sufficient quantity were used, it would dissolve the whole of that combination.

Muriatic acid is now to be poured in till the whole of the matter is dissolved. At first a flaky precipitate appears, because the acid combines with the alkali which kept it in solution. Then an effervescence takes place, owing to the decomposition of some carbonat of potass formed during the fusion. At the same time the flaky precipitate is redissolved; as is also that part of the matter which, not having been dissolved in the water, had remained at the bottom of the dish in the form of a powder. This powder, if it consists only of silica and alumina, dissolves without effervescence; but if it contains lime, an effervescence takes place.

If this solution in muriatic acid be colourless, we may conclude that it contains no metallic oxyd, or only a very small portion; if its colour be purplish red, it contains manganese; orange red indicates the presence of iron; and golden yellow the presence of chromum.

This solution is to be poured into a capsule of porcelain, covered with paper, and evaporated to dryness in a sand bath. When the evaporation is drawing towards its completion, the liquor assumes the form of jelly. It must then be stirred constantly with a glass or porcelain rod, in order to facilitate the disengagement of the acid and water, and to prevent one part of the matter from being too much, and another not sufficiently dried. Without this precaution, the silica and alumina would not be completely separated from each other.

When the matter is reduced almost to a dry powder, a large quantity of pure water is to be poured on it; and, after exposure to a slight heat, the whole is to be poured on a filter. The powder which remains upon the filter is to be washed repeatedly, till the water with which it has been washed ceases to precipitate silver from its solutions. This powder is the whole of *silica* which the stone that we are analysing c[illegible] It must first be dried between folds of blotting [illegible] then heated red hot in a platinum or silver cru[illegible] and weighed while it is yet warm. It ought to be a fine powder, of a white colour, not adhering to the fingers, and entirely soluble in acids. If it be coloured, it is contaminated with some metallic oxyd; and shews, that the evaporation to dryness has been performed at too high a temperature. To separate this oxyd, the silica must be boiled with an acid, and then washed and dried as before. The acid solution must be added to the water which passed through the filter, and which we shall denominate A. 300 How the silica is separated.

The watery solution A is to be evaporated till its quantity does not exceed 30 cubic inches, or nearly an English pint. A solution of carbonat of potass is then to be poured into it till no more matter precipitates. It ought to be boiled a few moments to enable all the precipitate to fall to the bottom. When the whole of the precipitate has collected at the bottom, the supernatant liquid is to be decanted off; and water being substituted in its place, the precipitate and water are to be thrown upon a filter. When the water has run off, the filter with the precipitate upon it is to be placed between folds of blotting paper. When the precipitate has acquired some consistence, it is to be carefully collected by an ivory knife, mixed with a solution of pure potass, and boiled in a porcelain capsule. If any alumina

(y) Part of this section is to be considered as an abstract of a treatise of Vauquelin on the analysis of stones, published in the *Annales de Chimie*, Vol. XXX. p. 66.

(z) Barytes has also been discovered in one single stone, the *staurolite*; but its presence in stones is so uncommon, that it can scarcely be looked for. The method of detecting it shall be noticed afterwards.

Analysis of Minerals.

301 And the alumina,

alumina or glucina be present, they will be dissolved in the potass; while the other substances remain untouched in the form of a powder, which we shall call B.

Into the solution of potass as much acid must be poured as will not only saturate the potass, but also completely redissolve any precipitate which may have at first appeared. Carbonat of ammonia is now to be added in such quantity that the liquid shall taste of it. By this addition the whole of the alumina will be precipitated in white flakes, and the glucina will remain dissolved, provided the quantity of carbonat of ammonia used be not too small. The liquid is now to be filtered, and the alumina which will remain on the filter is to be washed, dried, heated red hot, and then weighed. To see if it be really alumina, dissolve it in sulphuric acid, and add a sufficient quantity of sulphat or acetite of potass; if it be alumina, the whole of it will be converted into crystals of alum.

302 Glucina,

Let the liquid which has passed through the filter be boiled for some time, and the glucina, if it contains any, will be precipitated in a light powder, which may be dried and weighed. When pure, it is a fine, soft, very light, tasteless powder, which does not concrete when heated, as alumina does.

303 Lime,

The residuum B may contain lime, magnesia, and one or more metallic oxyds. Let it be dissolved in weak sulphuric acid, and the solution evaporated to dryness. Pour a small quantity of water on it. The water will dissolve the sulphat of magnesia, and the metallic sulphats; but the sulphat of lime will remain undissolved. Let it be heated red hot in a crucible, and weighed. The lime amounts to 0.41 of the weight.

Let the solution containing the remaining sulphats be diluted with a large quantity of water, let a small excess of acid be added, and then let a saturated carbonat of potass be poured in. The oxyds of chromum, iron, and nickel, will be precipitated, and the magnesia and oxyd of manganese will remain dissolved. The precipitate we shall call C.

304 Manganese,

Into the solution let a solution of hydrosulphuret of potass be poured, and the manganese will be precipitated in the state of a hydrosulphuret. Let it be calcined in contact with air, and weighed.

305 Magnesia,

The magnesia may then be precipitated by pure potass, washed, exposed to a red heat, and then weighed.

Let the residuum C be boiled repeatedly with nitric acid, then mixed with pure potass; and after being heated, let the liquid be decanted off.

306 Chromum,

Let the precipitate, which consists of the oxyds of iron and nickel, be washed with pure water; and let this water be added to the solution of the nitric acid and potass. That solution contains the chromum converted into an acid, Add to this solution an excess of muriatic acid, and evaporate till the liquid assumes a green colour; then add a pure alkali: The chromum precipitates in the state of an oxyd, and may be dried, and weighed.

307 Iron,

Let the precipitate, consisting of the oxyds of iron and nickel, be dissolved in muriatic acid; add an excess of ammonia: the oxyd of iron precipitates. Let it be washed, dried, and weighed.

308 And nickel.

Evaporate the solution, and the oxyd of nickel will also precipitate; and its weight may be ascertained in the same manner with the other ingredients.

The weights of all the ingredients obtained are now to be added together, and their sum total compared with the weight of the matter submitted to analysis. If the two are equal, or if they differ only by .03 or .04 parts, we may conclude that the analysis has been properly performed: but if the loss of weight be considerable, something or other has been lost. The analysis must therefore be repeated with all possible care. If there is still the same loss of weight, we may conclude that the stone contains some substance, which has either evaporated by the heat, or is soluble in water.

309 Method of detecting volatile bodies.

A fresh portion of the stone must therefore be broken into small pieces, and exposed in a porcelain crucible to a strong heat. If it contains water, or any other volatile substance, they will come over into the receiver; and their nature and weight may be ascertained.

If nothing comes over into the receiver, or if what comes over is not equal to the weight wanting, we may conclude that the stone contains some ingredient which is soluble in water.

310 Method of ascertaining whether stones contain potass.

To discover whether it contains *potass*, let the stone, reduced to an impalpable powder, be boiled five or six times in succession, with very strong sulphuric acid, applying a pretty strong heat towards the end of the operation, in order to expel the excess of acid; but taking care that it be not strong enough to decompose the salts which have been formed.

Water is now to be poured on, and the residuum, which does not dissolve, is to be
it becomes tasteless. The water
tered, and evaporated to dryness
any excess of acid which may be present. The salts are to be again dissolved in water; and the solution, after being boiled for a few moments, is to be filtered and evaporated to a consistence proper for crystallizing. If the stone contains a sufficient quantity of alumina, and if potass be present, crystals of alum will be formed; and the quantity of potass may be discovered by weighing them, it being nearly $\frac{1}{10}$th of their weight. If the stone does not contain alumina, or not in sufficient quantity, a solution of pure alumina in sulphuric acid must be added. Sometimes the alum,
present, does not appear for sever
and sometimes, when a great quan
sent, if the solution has been too much concentrated by evaporation, the sulphat of alumina prevents the alum from crystallizing at all. Care, therefore, must be taken to prevent this last source of error. The alum obtained may be dissolved in water, and barytic water poured into it as long as any precipitate forms. The liquor is to be filtered, and evaporated to dryness. The residuum will consist of potass and a little carbonat of potass. The potass may be dissolved in a little water. This solution, evaporated to dryness, gives us the potass pure; which may be examined and weighed.

Of soda.

If no crystals of alum can be obtained, we must look for some other substance than potass. The stone, for instance, may contain soda. The presence of this alkali may be discovered by decomposing the solution in sulphuric acid, already described, by means of ammonia. The liquid which remains is to be evaporated to dryness, and the residuum is to be calcined in a crucible. By this method, the sulphat of ammonia will be volatilized, and the soda will remain. It may be redissolved in water, crystallized, and examined.

If sulphuric acid does not attack the stone, as is often the case, it must be decomposed by fusion with soda,

Analysis of Minerals. da, in the same manner as formerly directed with potass. The matter, after fusion, is to be diluted with water, and then saturated with sulphuric acid. The solution is to be evaporated to dryness, the residuum again dissolved in water, and evaporated. Sulphat of soda will crystallize first; and by a second evaporation, if the stone contains potass and alumina, crystals of alum will be deposited.

The presence of potass may be discovered, by mixing with a somewhat concentrated solution of muriat of platinum, the salt obtained, either by decomposing the stone immediately by an acid, or by saturating with an acid the matter obtained by fusing the stone with soda. If any potass be present, a very red precipitate will be formed. This precipitate is a triple salt, composed of potass, muriatic acid, and oxyd of platinum. Ammonia, indeed, produces the same precipitate; but ammonia has not hitherto been discovered in stones.

312 Analysis of saline stones. In this manner may simple stones and aggregates be analysed. As to saline stones, their analysis must vary according to the acid which they contain. But almost all of them may be decomposed by one or other of two methods; of each of which we shall give an example.

I. Analysis of Carbonat of Strontites.

313 Of Carbonate. Klaproth analysed this mineral by dissolving 100 parts of it in diluted muriatic acid: during the solution, 30 parts of carbonic acid escaped. The solution crystallized in needles, and when dissolved in alcohol, burnt with a purple flame. Therefore it contained strontites. He dissolved a grain of sulphat of potass in six ounces of water, and let fall into it three drops of the muriatic solution. No precipitate appeared till next day. Therefore the solution contained no barytes; for if it had, a precipitate would have appeared immediately.

He then decomposed the muriatic acid solution, by mixing it with carbonat of potass. Carbonat of strontites precipitated. By the application of a strong heat, the carbonic acid was driven off. The whole of the earth which remained was dissolved in water. It crystallized; and when dried, weighed 69½ *.

* Klaproth's Beitrage, i. 260.

II. Analysis of Sulphat of Strontites.

Mr Vauquelin analysed an impure specimen of this mineral as follows:

314 Sulphate. On 200 parts of the mineral, diluted nitric acid was poured. A violent effervescence took place, and part of the mineral was dissolved. The undissolved portion, after being heated red hot, weighed 167. Therefore 33 parts were dissolved.

The nitric solution was evaporated to dryness: A reddish substance remained, which indicated the presence of oxyd of iron. This substance was redissolved in water, and some ammonia mixed with it; a reddish precipitate appeared, which, when dried, weighed 1, and was oxyd of iron. The remainder of the solution was precipitated by carbonat of potass. The precipitate weighed, when dried, 20, and possessed the properties of carbonat of lime. Therefore 200 parts of this mineral contain 20 of carbonat of lime, 1 of oxyd of iron, and the remainder of the 33 parts he concluded to be water.

The 167 parts, which were insoluble in nitric acid, were mixed with 500 parts of carbonat of potass, and 7000 parts of water, and boiled for a considerable time. The solution was then filtered, and the residuum washed and dried. The liquid scarcely effervesced with acids; but with barytes it produced a copious precipitate, totally indissoluble in muriatic acid. Therefore it contained sulphuric acid.

The undissolved residuum, when dried, weighed 129 parts. It dissolved completely in muriatic acid. The solution crystallized in needles; when dissolved in alcohol, it burnt with a purple flame; and, in short, had all the properties of muriat of strontites. Therefore these 129 parts were carbonat of strontites. Now, 100 parts of this carbonat contain 30 of carbonic acid; therefore 129 contain 38.7. Therefore the mineral must contain in 200 parts 90.3 of strontites.

Now, the insoluble residuum of 167 parts was pure sulphat of strontites; and we have seen that it contained 90.3 of strontites. Therefore the sulphuric acid must amount to 76.7 parts †.

† Jour. de Min. No xxxvi. p. 1.

Nearly in the same manner as in the first of these examples, may the analysis of carbonat of lime and barytes be performed; and nearly in the same manner with the second, we may analyse the sulphats of lime and barytes.

315 Phosphats. Phosphat of lime may be dissolved in muriatic acid, and the lime precipitated by sulphuric acid, and its quantity ascertained by decomposing the sulphat of lime obtained. The liquid solution may be evaporated to the consistence of honey, mixed with charcoal powder, and distilled in a strong heat. By this means phosphorus will be obtained. The impurities with which the phosphat may be contaminated will partly remain undissolved, and be partly dissolved, in muriatic acid. They may be detected and ascertained by the rules laid down in the second section of this chapter.

316 Fluats. The fluat of lime may be mixed with sulphuric acid and distilled. The fluoric acid will come over in the form of gas, and its weight may be ascertained. What remains in the retort, which will consist chiefly of sulphat of lime, may be analysed by the rules already laid down.

317 And borats. The borat of lime may be dissolved in nitric or sulphuric acid. The solution may be evaporated to dryness, and the boracic acid separated from the residuum by means of alcohol, which will dissolve it without acting on any of the other ingredients. The remainder of the dry mass may be analysed by the rules laid down in Sect. II. of this Chapter.

Sect. III. *Of the Analysis of Combustibles.*

The only combustibles of whose analysis it will be necessary to speak are coals and sulphur; for the method of analysing the diamond and oil has already been given in the article Chemistry, *Suppl.*

318 Earths of coal how examined. Coal is composed of carbon, bitumen, and some portion of earth. The earths may be detected by burning completely a portion of the coal to be analysed. The ashes which remain after incineration consist of the earthy part. Their nature may be ascertained by the rules laid down in Sect. II. of this Chapter.

For the method of ascertaining the proportion of carbon and bitumen in coal, we are indebted to Mr Kirwan.

319 Method of detecting the relative proportions of charcoal and bitumen. When nitre is heated red hot, and charcoal is thrown on it, a violent detonation takes place; and if the quantity of charcoal be sufficient, the nitre is completely decomposed. Now, it requires a certain quantity of pure carbon

Analysis of Minerals.

carbon to decompose a given weight of nitre. From the experiments of Lavoisier, it follows, that when the detonation is performed in close vessels under water, 13.21 parts of charcoal are capable of decomposing 100 parts of nitre*. But when the detonation is performed in an open crucible, a smaller proportion of charcoal is necessary, because part of the nitre is decomposed by the action of the surrounding air. Scheele found, that under these circumstances 10 parts of plumbago were sufficient to decompose 96 parts of nitre, and Mr Kirwan found, that nearly the same quantity of charcoal was sufficient for producing the same effect.

Macquer long ago observed, that no volatile oily matter will detonate with nitre, unless it be previously reduced to a charcoal; and that then its effect upon nitre is precisely proportional to the charcoal which it contains †. Mr Kirwan, upon trying the experiment with *vegetable pitch* and *maltha*, found, that these substances did not detonate with nitre, but merely burn upon its surface with a white or yellow flame; and that after they were consumed, nearly the same quantity of charcoal was necessary to decompose the nitre which would have been required if no bitumen had been used at all ‡. Now coals are chiefly composed of charcoal and bitumen. It occurred therefore to Mr Kirwan, that the quantity of charcoal which any coal contains may be ascertained by detonating it with nitre: For since the bitumen of the coal has no effect in decomposing nitre, it is evident that the detonation and decomposition must be owing to the charcoal of the coal; and that therefore the quantity of coal necessary to decompose a given portion of nitre will indicate the quantity of carbon which it contains: and the proportion of charcoal and earth which any coal contains being ascertained, its bituminous part may be easily had from calculation.

The crucible which he used in his experiments was large; it was placed in a wind furnace at a distance from the flue, and the heat in every experiment was as equal as possible. The moment the nitre was red hot, the coal, previously reduced to small pieces of the size of a pin head, was projected in portions of one or two grains at a time, till the nitre would no longer detonate; and every experiment was repeated several times to ensure accuracy.

He found, that 480 grains of nitre required 50 grains of Kilkenny coal to decompose it by this method. Therefore 10 grains would have decomposed 96 of nitre; precisely the quantity of charcoal which would have produced the same effect. Therefore Kilkenny coal is composed almost entirely of charcoal.

Cannel coal, when incinerated, left a residuum of 3.12 in the 100 parts of earthy ashes. 66.5 grains of it were required to decompose 480 grains of nitre; but 50 parts of charcoal would have been sufficient: therefore 66.5 grains of cannel coal contain 50 grains of charcoal, and 2.08 of earth; the remaining 14.42 grains must be bitumen. In this manner may the composition of any other coal be ascertained.

320
Method of analysing sulphur.

As for sulphur, in order to ascertain any accidental impurities with which it may be contaminated, it ought to be boiled in thirty times its weight of water, afterwards in diluted muriatic acid, and lastly in diluted nitro-muriatic acid. These substances will deprive it of all its impurities without acting on the sulphur itself, at least if the proper cautions be attended to. The sulphur may then be dried and weighed. The deficiency in weight will mark the quantity of the substances which contaminate the sulphur. The solutions may be evaporated and examined, according to the rules laid down in the second and fourth sections of this chapter.

* Mem. Scav. Etrang. xi. 626.

† Macquer's Dictionary, 2d edit. p. 481.

‡ Mineralogy, ii. 522.

Sect. IV. *Of the Analysis of Ores.*

321
No general method of analysing ores.

The method of analysing ores must vary considerably, according to the metals which they are suspected to contain. A general method, therefore, of analysing ores would be of no use, even if it could be given, because it would be too complicated ever to be practised. We shall content ourselves with exhibiting a sufficient number of the analyses of ores, to take in most of the cases which can occur He who wishes for more information on the subject, may consult the treatise of Bergman on the *Analyses of Ores*; Mr Kirwan's treatise on the same subject; and, above all, he ought to study the numerous analyses of ores which have been published by Mr Klaproth.

I. Analysis of Red Silver Ore.

322
Method of analysing red silver ore.

Mr Vauquelin analysed this ore as follows:

He reduced 100 parts of it to fine powder, poured over it 500 parts of nitric acid previously diluted with water, and applied a gentle heat to the mixture. The colour of the powder, which before the mixture with nitric acid was a deep purple, became gradually lighter, till at last it was pure white. During this change no nitrous gas was extricated; hence he concluded, that the metals in the ore were in the state of oxyds.

When the nitric acid, even though boiled gently, did not appear to be capable of dissolving any more of the powder, it was decanted off, and the residuum, after being carefully washed, weighed 42.06.

Upon these 42.06 parts concentrated muriatic acid was poured; and by the application of heat, a considerable portion was dissolved. The residuum was repeatedly washed with muriatic acid, and then dried. Its weight was 14.6666. One portion of these 14.6666 parts, when thrown upon burning coals, burnt with a blue flame and sulphureous smell. Another portion sublimed in a close vessel without leaving any residuum. In short, they had all the properties of sulphur. Therefore 100 parts of red silver ore contain 14.6666 of sulphur.

The muriatic acid solution was now diluted with a great quantity of water; it became milky, and deposited a white flaky powder, which when washed and dried weighed 21.25. This powder, when heated with tartar in a crucible, was converted into a bluish white brittle metal, of a foliated texture, and possessing all the other properties of antimony. Red silver ore therefore contains 21.25 of oxyd of antimony.

The solution in nitric acid remained now to be examined. When muriatic acid was poured into it, a copious white precipitate appeared, which, when washed and dried, weighed 72.66. It had all the properties of muriat of silver. According to Mr Kirwan's tables, 72.66 of muriat of silver contain 60.57 of oxyd of silver. Therefore red silver ore, according to this analysis, is composed of

60.57	oxyd of silver,
21.25	oxyd of antimony,
14.66	sulphur.
96.48	

The

The loss, which amounts to 3.52 parts, is to be ascribed to unavoidable errors which attend such experiments.

II. Antimoniated Silver Ore.

323 Analysis of antimoniated silver ore.

Klaproth analysed this ore as follows:

On 100 parts of the ore, reduced to a fine powder, he poured diluted nitric acid, raised the mixture to a boiling heat, and after pouring off the acid, added new quantities repeatedly, till it would dissolve nothing more. The residuum was of a greyish yellow colour, and weighed, when dry, 26.

These 26 parts he digested in a mixture of nitric and muriatic acid; part was dissolved, and part still remained in the form of a powder. This residuum, when washed and dried, weighed 13 parts. It had the properties of sulphur; and when burnt, left a residuum of one part, which had the properties of silica. Antimoniated silver ore, therefore, contains, in the 100 parts, 12 parts of sulphur and 1 of silica.

When the nitro-muriatic solution was diluted with about 20 times its weight of water, a white precipitate appeared; which, when heated to redness, became yellow. Its weight was 13. No part evaporated at a red heat: therefore it contained no arsenic. On burning coals, especially when soda was added, part was reduced to a metal, having the properties of antimony; and in a pretty high heat, the whole evaporated in a grey smoke. These 13 parts were therefore oxyd of antimony: They contain about 10 parts of metallic antimony; and as the state of oxyd was produced by the action of the nitric acid, we may conclude, that antimoniated silver ore contains 10 parts of antimony.

The nitric acid solution remained still to be examined. It was of a green colour. When a solution of common salt was poured in, a white precipitate was obtained, which possessed the properties of muriat of silver. When dried, it weighed 87.75 parts; and when reduced, 65.81 parts of pure silver were obtained from it. Antimoniated silver ore, therefore, contains 65.81 of silver.

Into the nitric acid solution, thus deprived of the silver, he dropped a little of the solution of sulphat of soda; but no precipitate appeared. Therefore it contained no lead.

He supersaturated it with pure ammonia, on which a grey precipitate appeared. When dried, it weighed 5 parts. This, on burning coals, gave out an arsenical smell. It was redissolved in nitric acid; sulphurated alkali occasioned a smutty brown precipitate; and prussic alkali a prussian blue, which, after torrefaction, was magnetic. Hence he concluded, that these 5 parts were a combination of iron and arsenic acid.

The nitric solution, which had been supersaturated with ammonia, was blue; he therefore suspected that it contained copper. To discover this, he saturated it with sulphuric acid, and put into it a polished plate of iron. The quantity of copper was so small, that none could be collected on the iron.

III. Grey Copper Ore.

324 Analysis of grey copper ore.

Klaproth analysed this ore as follows:

Three hundred grains of it, not completely freed from its matrix, were reduced to a fine powder; four times their weight of nitric acid was poured on them, and the whole was digested. The acid was then poured off, and an equal quantity again digested on the residuum. The two acid solutions were mixed together. The residuum was of a yellowish grey colour, and weighed 188 grains.

On this residuum six times its weight of muriatic acid was boiled. The residuum was washed, first with muriatic acid, and afterwards with alcohol, and the washings added to the muriatic acid solution. The residuum, when dried, weighed 105.5 grains. Part of it burned with a blue flame; and was therefore sulphur. The residuum amounted to 80.25 grains, and had the properties of silica. When melted with black flux, about $\frac{3}{4}$ths of a grain of silver were obtained from it. Thus 300 parts of grey copper ore contain 25.25 gr. of sulphur, and 79.5 of silica.

The muriatic acid solution, which was of a light yellow colour, was concentrated by distillation, a few crystals of muriat of silver appeared in it, which contained about $\frac{1}{4}$th grain of silver. The solution, thus concentrated, was diluted with a great quantity of water; a white precipitate was deposited, which, when dried, weighed 97.25 grains. It possessed the properties of oxyd of antimony, and contained 75 grains of antimony. Therefore 300 grains of grey copper ore contain 70 of antimony.

The nitric acid solution was of a clear green colour. A solution of common salt occasioned a white precipitate, which was muriat of silver, and from which 31.5 grains of silver were obtained.

A little sulphat of potass, and afterwards sulphuric acid, were added, to see whether the solution contained lead; but no precipitate appeared.

The solution was then supersaturated with ammonia; a loose fleaky brownish red precipitate appeared, which, when heated to redness, became brownish black; and weighed $9\frac{1}{4}$th grains. This precipitate was dissolved in muriatic acid; half a grain of matter remained undissolved, which was silica. The muriatic acid solution, when prussic alkali was added, afforded a blue precipitate; and soda afterwards precipitated 1.5 grains of alumina. Therefore 300 grains of grey copper ore contain 7.25 grains of iron, and 1.5 of alumina.

Into the nitric solution supersaturated with ammonia, and which was of an azure blue colour, a polished plate of iron was put: By this method 69 grains of copper were obtained.

IV. Sulphuret of Tin.

Klaproth analysed this ore as follows*:

On 120 grains of the ore reduced to powder, six times their weight of nitro muriatic acid, composed of 2 parts of muriatic, and 1 of nitric acid, were poured. 325 Analysis of sulphuret of tin.

There remained undissolved 43 grains, which had the appearance of sulphur; but containing green spots, was suspected not to be pure. After a gentle combustion, 13 grains remained; 8 of which were dissolved in nitro-muriatic acid, and added to the first solution. The remaining 5 were separated by the filtre, and heated along with wax. By this method about a grain of matter was obtained, which was attracted by the magnet; and which therefore was iron. The residuum weighed 3 grains, and was a mixture of alumina and silica. Thus 120 grains of sulphuret of tin contain 30 grains of sulphur, 1 of iron, and 3 of alumina and silica.

* *Observations on the Fossils of Cornwall*, p. 48.

Analysis of Minerals.

The nitro-muriatic solution was completely precipitated by potash. The precipitate was of a greyish green colour. It was washed and dried, and again dissolved in diluted muriatic acid. Into the solution a cylinder of pure tin was put, which weighed exactly 217 grains. The solution became gradually colourless, and a quantity of copper precipitated on the cylinder of tin, which weighed 44 grains. To see whether it was pure, a quantity of nitric acid was digested on it; the whole was dissolved, except one grain of tin. Therefore 120 grains of sulphuret of tin contains 43 grains of copper.

The cylinder of tin now weighed only 128 grains; so that 89 grains had been dissolved. Into the solution a cylinder of zinc was put; upon which a quantity of tin precipitated. When washed and dried, it weighed 130 grains. The tin he melted with tallow and powdered charcoal; and when cold, he washed off the charcoal. Among the tin globules were found some black flocculi of iron, which weighed one grain. Deducting this grain, and the 89 grains of the tin cylinder which had been dissolved, we see that the 120 grains of sulphuret of tin contained 40 grains of tin besides the grain which had been detected in the copper.

V. Plumbiferous Antimoniated Silver Ore.

316 Analysis of plumbiferous antimoniated silver ore.

Klaproth analysed this ore as follows:

He digested 400 grains of it, reduced to a fine powder, first in five times its weight of nitric acid, and then in twice its weight of the same acid. He then diluted this last portion of acid with eight times its weight of water, and continued the digestion. The undissolved residuum, when washed and dried, weighed 326 grains.

On this residuum he boiled muriatic acid repeatedly. The solution, on cooling, deposited acicular crystals. These he carefully separated, and put by. The undissolved residuum weighed 51 grains. It had the properties of sulphur. When burned, it left one grain of silica.

The muriatic acid solution was concentrated to half its former bulk by distillation: this made it deposite more acicular crystals. He continued the distillation as long as any crystals continued to appear. He then collected the whole of these crystals together. They had the properties of muriat of lead. When mixed with twice their weight of black flux, and heated in a crucible lined with charcoal, they yielded $160\frac{1}{8}$ grains of lead.

Sulphuret of ammonia was now added to the muriatic acid solution; an orange-coloured precipitate appeared, which shewed that the solution contained antimony. It was precipitated by a copious effusion of water, and by soda. The oxyd of antimony being reduced to a mass with Spanish soap, mixed with black flux, and heated in a lined crucible, yielded 28.5 grains of antimony.

Into the nitric acid solution, obtained by the first part of the process, a solution of muriat of soda was dropped; a white precipitate was deposited, and over it acicular crystals. These crystals he dissolved, by pouring boiling water on the precipitate. The water was added to the nitric acid solution. The white precipitate was muriat of silver: when heated with twice its weight of soda, it yielded 81.5 grains of silver.

He now concentrated the nitric acid solution by evaporation; and then adding a solution of sulphat of soda, a white precipitate was obtained, which had the properties of sulphat of lead, and weighed 43 grains. It contained 32 grains of pure lead.

Analysis of Mineral.

He now poured ammonia into the solution; a pale brown precipitate was obtained, which weighed 40 grains, and which appeared to consist of oxyd of iron and alumina. He redissolved it in nitric acid, precipitated the iron by prussic alkali, and the alumina by soda. The alumina, after being heated to redness, weighed 28 grains; consequently the oxyd of iron was 12 grains, which is equivalent to 9 grains of iron.

VI. Molybdat of Lead.

Mr Hatchett analysed this ore as follows †:

310

317 Analysis of molybdat

On 250 grains of the ore, reduced to a fine powder, he poured an ounce of strong sulphuric acid, and digested the mixture in a strong heat for an hour. When the solution was cool, and had settled, he decanted it off, and washed the undissolved powder with pure water, till it came away tasteless. This operation was repeated twice more; so that three ounces of sulphuric acid were used. All these solutions were mixed together, and filtered.

Four ounces of a solution of carbonat of soda were poured upon the powder which remained undissolved, and which consisted of sulphat of lead. The mixture was boiled for an hour, and then poured off. The powder was then washed, and diluted nitric acid poured on it: The whole was dissolved, except a little [illegible] powder, which, when washed, and dried on a filter by the heat of boiling water, weighed seven-tenths of a grain. It possessed the properties of silica.

The nitric acid solution was saturated with pure soda; a white precipitate was obtained, which, when washed, and dried for an hour in a heat rather below redness, weighed 146 grains. It possessed the properties of oxyd of lead.

To see whether this oxyd of lead contained any iron, it was dissolved in diluted nitric acid, and the lead precipitated by sulphuric acid. The solution was then saturated with ammonia; a brown powder precipitated, which, when dried, weighed one grain, and had the properties of oxyd of iron.

The sulphuric acid solution was of a pale blue colour: It was diluted with 16 times its weight of pure water, and then saturated with ammonia. It became of a deep blue colour, and appeared turbid. In 24 hours a pale yellow precipitate subsided, which, when collected on a filter, and dried by a boiling water heat, weighed 4.2 grains. Its colour was yellowish brown. Muriatic acid dissolved it, and prussiat of potash precipitated it from its solution in the state of prussian blue. It was therefore oxyd of iron.

The sulphuric acid solution, saturated with ammonia, was gradually evaporated to a dry salt. This salt was a mixture of molybdat of ammonia and sulphat of ammonia. A strong heat was applied, and the distillation continued till the whole of the sulphat of ammonia was driven off; and to be certain that this was the case, the fire was raised till the retort became red hot. The residuum in the retort was a black blistered mass; three ounces of nitric acid, diluted with water, were poured upon it, and distilled off. The operation was again repeated.

† Phil. Tran.

peated. By this method the oxyd of molybdenum was converted into a yellow powder, which was yellow acid of molybdenum. It weighed 95 grains.

VII. Grey Ore of Manganese.

Analysis of grey ore of manganese.

Mr Vauquelin analysed this ore as follows ‡ :

When 200 grains of it were exposed to a strong heat in a retort, there came over 10 grains of water, and 18 cubic inches of oxygen gas, mixed with a little carbonic acid gas. The mineral now weighed only 176 grains. Therefore the weight of the gas was 14 grains.

On 200 grains of the same mineral muriatic acid was poured, and heat applied. 75 cubic inches of oxy muriatic acid gas came over, which, though mixed with some carbonic acid gas, enflamed metals when reduced to powder. When no more gas came over, the residuum was boiled. The whole was dissolved, except a white powder, which weighed 12 grains, and which possessed the properties of silica.

Carbonat of potass was poured into the solution; a white precipitate was obtained, which became black by exposure to the air, and weighed 288 grains. Strong nitric acid was boiled on it repeatedly to dryness. It became of a deep black colour, and, when well washed with water and dried, weighed 164 grains. This powder was black oxyd of manganese.

To see whether it contained iron, nitric acid, with a little sugar, was poured upon it, and digested on it. The acid dissolved it completely. Therefore no oxyd of iron was present.

Into the water with which the black oxyd of manganese had been washed, carbonat of potass was poured; a white powder precipitated, which, when dried, weighed 149 grains, and which possessed the poperties of carbonat of lime.

‡ Jour. de Min. xvii. p. 12.

VIII. Wolfram.

319
Analysis of wolfram.

Messrs Vauquelin and Hecht analysed this mineral as follows:

On 200 parts of Wolfram in powder, three times its weight of muriatic acid were poured, and the mixture boiled for a quarter of an hour: a yellow powder appeared, and the solution was of a brown colour. The acid was allowed to cool, and then carefully decanted off, and the residuum washed. The residuum was then digested for some hours with ammonia, which dissolved a part of it. The residuum was washed, and new muriatic acid again poured over it; then the residuum was digested with ammonia, as before: and the operation was continued till the whole wolfram was dissolved.

All the ammoniacal solutions being joined together, were evaporated to dryness, and the salt which remained was calcined: a yellow powder was obtained; it weighed 134 grains, and was yellow acid of tungsten.

Into the muriatic acid solutions, which were all mixed together, a sufficient quantity of sulphuric acid was poured to decompose all the salts. The solution was then evaporated to dryness; and the salts which were obtained by this evaporation were redissolved in water. A white powder remained, which weighed three grains, and which possessed the properties of silica.

The excess of acid of the solution was saturated with carbonat of potass; the liquor became brown, but nothing precipitated. When boiled, a red powder precipitated, and the brown colour disappeared. The addition of more carbonat of potass caused a farther precipitation of a yellowish powder. This precipitate consisted of the oxyds of iron and manganese combined. Nitric acid was distilled off it repeatedly; it was then boiled in acetous acid. The acetous solution was precipitated by potass. Nitric acid was again distilled off it, and it was again boiled in acetous acid. This process was repeated till nitric acid produced no further change. The different powders which could not be dissolved in the acetous acid were collected, mixed with a little oil, and heated red hot. The powder became black, and was attracted by the magnet. It was therefore oxyd of iron. It weighed 36 grains.

The acetous solution contained the oxyd of manganese: It was precipitated by an alkali, and, when dried, weighed 12.5 grains.

IX. Oxyd of Titanium and Iron.

330
Analysis of oxyd of titanium and iron.

Vauquelin analysed this ore as follows:

A hundred parts of the ore, reduced to a fine powder, and mixed with 400 parts of potass, were melted in a silver crucible for an hour and a half. When cool, the mixture was diluted with water; a powder remained of a brick red colour, which, when washed and dried, weighed 124 parts.

The watery solution had a fine green colour; when an excess of muriatic acid was added, it became red. By evaporation the liquor lost its colour. When evaporated to dryness, a salt remained, which was totally dissolved by water. From this solution carbonat of potass precipitated two parts, which had the properties of oxyd of manganese.

The 124 parts of residuum were boiled in a solution of pure potass for an hour. The solution was saturated with an acid, filtered, and carbonat of potass added, which precipitated three parts. These had the properties of oxyd of titanium.

The remainder of the 124 parts of residuum, which still was undissolved, was boiled with diluted muriatic acid. The liquor became yellow, and deposited 46 parts of a white powder, with a tint of red. This powder was soluble in sulphuric and muriatic acids: from these solutions, it was precipitated of a brick red colour by the infusion of nut galls; of a green colour by sulphuret of ammonia and prussiat of potass; and of a white colour by carbonat of potass and pure ammonia. A rod of tin made these solutions red; a rod of zinc made them violet. These 46 parts, therefore, are oxyd of titanium.

The muriatic solution, from which these 46 parts were deposited, formed, with prussiat of potass, a prussian blue; and ammonia precipitated from it 50 parts, which had the properties of yellow oxyd of iron.

I N D X.

Petrilite,

Mirabeau. MIRABEAU (Honnoré Gabriel, Comte de), well known both by his writings, and the active part which he took in bringing about the French revolution, was born in 1749 of a noble family. Throughout life, he diſplayed a ſpirit averſe from every reſtraint, and was one of thoſe unhappy geniuſes in whom the moſt brilliant talents ſerve only as a ſcourge to themſelves and all around them. It is told by his democratical panegyriſts, as a wonderful proof of family tyranny under the old government, that not leſs than 67 *lettres de cachet* had been obtained by Mirabeau the father againſt this ſon and others of his relatives. This ſtory, if true, proves, with at leaſt equal force, what many anecdotes confirm, that, for his ſhare of them, the ſon was not leſs indebted to his own ungovernable diſpoſition than to the ſeverity of his parent. He was indeed a monſter of wickedneſs. Debauchery, gaming, impiety, and every kind of ſenſuality, were not enough for him. He was deſtitute of decency in his vices; and to ſupply his expences, ſcrupled not to perform tricks which would diſgrace a thief catcher. His father and mother diſagreeing, commenced a proceſs of ſeparation; when Mirabeau, juſt liberated from priſon for a groſs miſdemeanor, was in want of money. He went to his father, ſided with him againſt his mother, on whom he poured a torrent of invective; and, for [illegible] guineas, wrote his father's memorial for the court. He then went to his mother; and by a ſimilar conduct got the ſame ſum from her; and both memorials were preſented. That the father of ſuch a man ſhould frequently get him ſhut up in priſon, can excite no ſurpriſe; for confinement only could withhold him from the perpetration of crimes.

The talents of Mirabeau led him frequently to employ his pen; and his publications form the chief epochas of his life. His firſt publication was, 1. *Eſſai ſur le Deſpotiſme*, "An Eſſay on Deſpotiſm," in 8vo. Next, in one of his confinements, he wrote, 2. a work in 2 vols 8vo, *On Lettres de Cachet*. 3. *Conſiderations ſur l'Ordre de Cincinnatus*, 8vo. A remonſtrance againſt the order of Cincinnatus, propoſed at one time to be eſtabliſhed in America. The public opinion in America favoured this remonſtrance, and it proved effectual. 4. His next work was in favour of the Dutch, when Joſeph II. demanded the opening of the Scheldt, in behalf of the Brabançons. It is entitled, *Doutes ſur la Liberté de l'Eſcaut*, 8vo. 5. *Lettre à l'Empereur Joſeph II. ſur ſon Reglement concernant l'Emigration*; a pamphlet of forty pages, in 8vo. 6. *De la Caiſſe d'Eſcompte*; a volume in 8vo, written againſt that eſtabliſhment. 7. *De la Banque d'Eſpagne*, 8vo; a remonſtrance againſt eſtabliſhing a French bank in Spain. A controverſy

PLATE XXXVI.

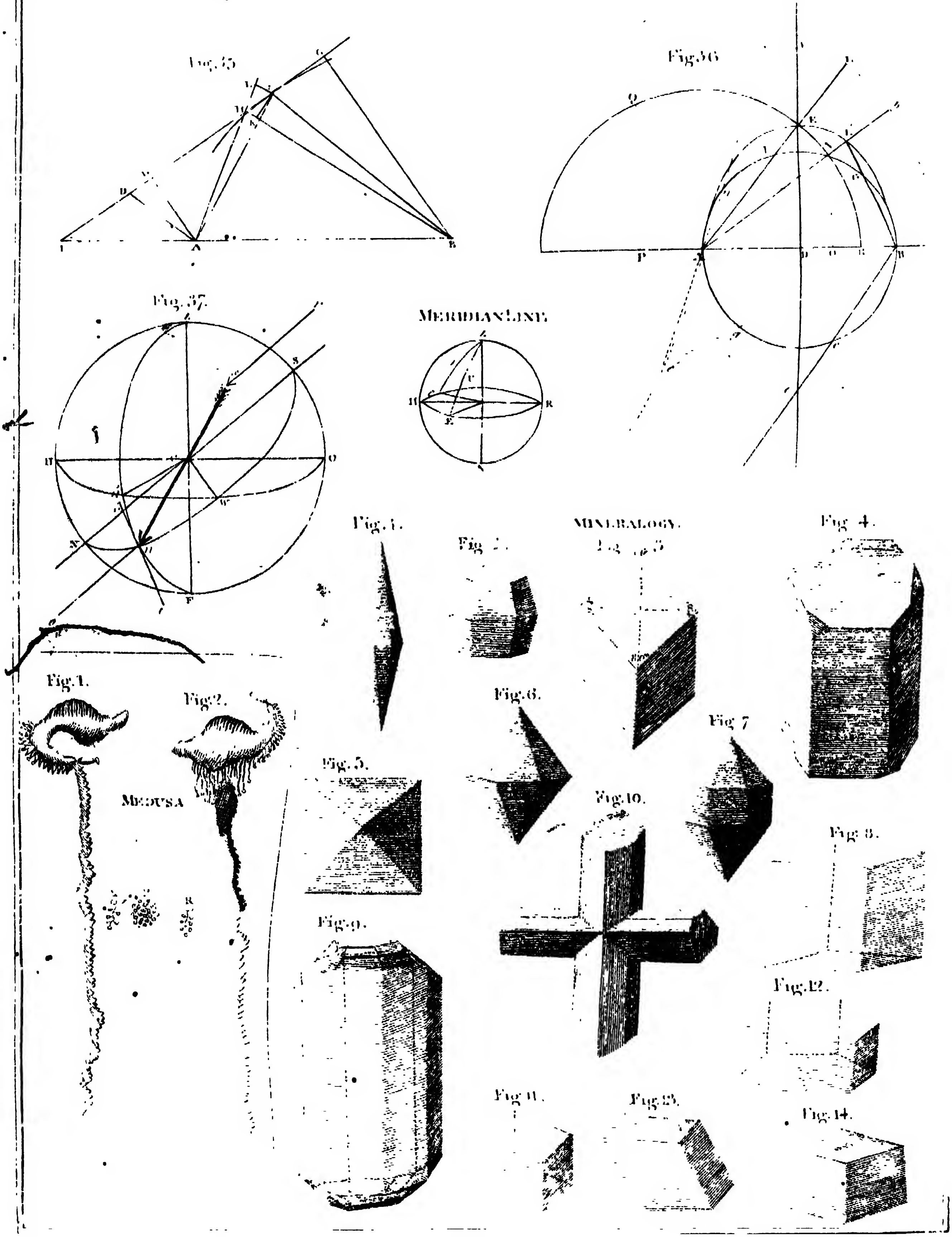
Fig. 35
Fig. 36
Fig. 37
MERIDIAN LINE
MINERALOGY
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10
Fig. 11
Fig. 12
Fig. 13
Fig. 14
Fig. 1
Fig. 2
MEDUSA

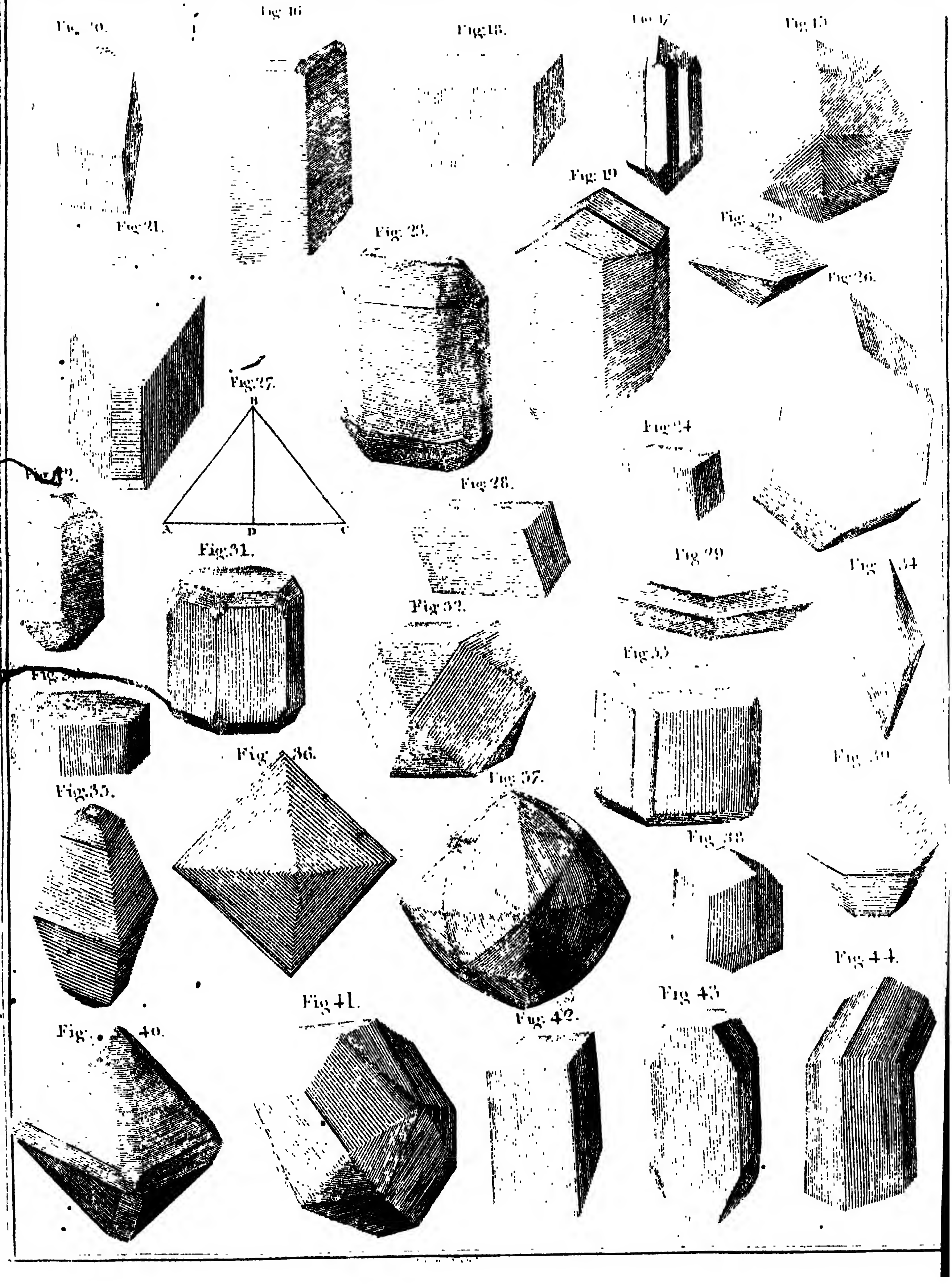
Fig. 16.
Fig. 18.
Fig. 15.
Fig. 19.
Fig. 21.
Fig. 23.
Fig. 26.
Fig. 27.
B
A
D
C
Fig. 24.
Fig. 28.
Fig. 31.
Fig. 29.
Fig. 32.
Fig. 33.
Fig. 36.
Fig. 35.
Fig. 37.
Fig. 38.
Fig. 44.
Fig. 41.
Fig. 43.
Fig. 42.
Fig. 40.

controversy arising upon this subject, he wrote again upon it. 8. Two pamphlets on the monopoly of the water company in Paris.

Soon after the publication of these works, he was sent in a public character to the court of Berlin; where he conducted the king's affairs just as he had formerly done those of his father and mother, fully ready to sacrifice all parties, and to sell himself to the highest bidder. With such a disposition, he could not long avoid the notice of the Prussian illuminees; and Nicolai Biester, Gedicke, and Leuchsenring, soon became his constant companions. At Brunswick he met with Mauvillon, the worthy disciple of Philo Knigge, and at that time a professor in the Caroline college. This was the man who initiated the profligate Marquis in the last mysteries of illuminism.

Mirabeau was still at Berlin when Frederick II. died. That monarch, as is well known, was a naturalist, who, holding this life for his all, encouraged the propagation of infidelity in his dominions, from which resulted the very worst consequences to the peace of society. Of this truth his successor Frederick William was duly sensible; and determined to support the church establishment in the most peremptory manner, consistent with the principles of religious toleration. He published, therefore, soon after his accession, an edict on religion, which is a model worthy of imitation in every country; but it was attacked with the greatest virulence in numberless publications. It was called an unjustifiable tyranny over the consciences of men; the dogmas supported by it were termed absurd superstitions; the king's private character and his religious opinions were ridiculed and scandalously abused. The most daring of these attacks was a collection of anonymous letters on the constitution of the Prussian states, universally believed to be the composition of Mirabeau, who certainly wrote a French translation, with a preface and notes more impudent than the work itself. The monarch is declared to be a tyrant; the people of the Prussian dominions are addressed as a parcel of tame wretches, crouching under oppression; and the inhabitants of Silesia, represented as still in a worse condition, are repeatedly called upon to rouse themselves, and assert their rights.

About this time he published, 9. An *Essai sur la Secte des Illuminés;* one of the strangest and most impudent books that ever appeared. In it he describes a sect existing in Germany, called the *Illuminated;* and says, that they are the most absurd and gross fanatics imaginable, waging war with every appearance of reason, and maintaining the most *ridiculous superstitions.* He gives some account of these, and of their rituals and ceremonies, as if he had seen them all; yet no such society as he describes ever existed: and Mirabeau employed his powers of deception, merely to screen from observation the real *illuminati,* by holding out to the rulers of states this *ignis fatuus* of his own brain. For a while the essay certainly contributed to blind the eyes of the German princes; and Nicolai, with others of the junto, adopting the whim, called Mirabeau's fanatics *Obscuranten,* and joined with him in placing on the list of *Obscuranten* several persons whom they wished to make ridiculous.

Long before his initiation in the mysteries of illuminism, Mirabeau had been acquainted with all the revolutionary powers of the masonic lodges; nor did he, when initiated, undervalue those which flowed, or might flow, from Weishaupt's inventive genius. On his return to France, he began to introduce the new mysteries among some of his masonic brethren. His first associate was the Abbé Talleyrand de Perigord, who had already begun to act the part of Judas in the first order of the church. But to have only introduced the mysteries was not sufficient for the Marquis; he would have teachers come from Germany, who were better versed than he was in the illuminizing arts. Well acquainted with the reasons that had induced the chiefs of the order to defer the conversion of France, he found means to convince them, that the time was now come for the accomplishment of their views; and at his request a deputation was sent by Spartacus to illuminize that great kingdom. See ILLUMINATI, n° 40, 41, *Suppl.*

When the assembly of Notables was convened at Paris, Mirabeau foretold that it would soon be followed by a meeting of the States; and at that period he published a volume against the stockjobbing, then carried to a great height, intituled, 10. *Denonciation de l'agiotage au Roi, et a l'Assemblée de Notables,* 8vo. A *lettre de cachet* was issued against him in consequence of this publication; but he eluded pursuit, and published a pamphlet as a sequel to the book. His next work was against M. Necker, 11. *Lettre á M. de Cretelle, sur l'Administration de M. Necker,* a pamphlet in 8vo. 12. A volume, in 8vo. against the Stadtholdership: *Aux Bataves, sur le Stadthouderat.* 13. *Observations sur la maison de force appellé Bicetre,* an 8vo pamphlet. 14. Another tract, intitled, *Conseils a un jeune Prince qui sent la nécessité de refaire son education.* 15. He now proceeded to a larger and more arduous work than any he had yet published, on the Prussian monarchy under Frederick the Great: *De la Monarchie Prussienne sous Frédéric le Grand,* 4 vols, 4to, or eight in 8vo. In this work, he undertakes to define precisely how a monarchy should be constituted. When the orders were issued for convening the States general, Mirabeau returned into Provence; and at the same time published, 16. *Histoire Secrette de la Cour de Berlin,* two volumes of letters on the Secret History of the Court of Berlin. This work was condemned by the parliament of Paris, for the unreserved manner in which it delivered the characters of many foreign princes. As the elections proceeded, he offered himself a candidate in his own order at Aix; but he was so abhorred by the noblesse, that they not only rejected him, but even drove him from their presence. This affront settled his measures, and he determined on their ruin. He went to the commons, disclaimed his being a gentleman, set up a little shop in the market-place of Aix, where he sold trifles; and now, fully resolved what line he should pursue, he courted the commons, by joining in all their excesses against the noblesse, and was at last returned a member of the assembly.

In consequence of this, he went to Paris; where the part he took was active, and such as tended, in general, to accelerate all the violences of the revolution. He now published periodically, 17. his *Lettres à ses Commettans,* Letters to his Constituents, which form, when collected, [illegible] vols, 8vo. It is supposed, that the fatal measure of the junction of the three orders into one national

tional assembly, was greatly promoted by these letters. The public events of these times, and the part taken in them by Mirabeau, are the subject of general history. He lived to see the constitution of 1789 established, but not to see its consequences—the destruction of the monarchy, the death of the king, and the ruin of all property! He was accused, as well as the duke of Orleans, of hiring the mob which attacked Versailles on the 5th and 6th of October 1789; but with him was also acquitted by the tribunal of the Châtelet. The dominion of his eloquence in the National Assembly had long been absolute, and, on the 29th of January 1791, he was elected president. At the latter end of March, in the same year, he was seized by a fever, and died on the 2d of April.

The talents of Mirabeau will not be doubted, though they were certainly rather brilliant than profound. To be noticed, and to lead, were the sole objects of his ambition; and for the attainment of them, he took the side of the discontented, as the best field for his matchless eloquence. Yet there was no man more devoted to the principles of a court than this Marquis, provided he could have a share in the administration; and a share he would have obtained, if any thing moderate would have satisfied him: But he thought nothing worthy of him but a place of active trust, and a high department; stations which all knew him not qualified to fill. Wanting knowledge of great things, he was learned only in the bustling detail of intrigue, and would, at any time, have sacrificed his dearest friend, and the interests of his country, for an opportunity of exercising his brilliant eloquence, and indulging his propensity to satire and lampoon. But the greatest obstacle to his advancement under the old government was the abject worthlessness of his character. Drinking was the only vice in which he did not indulge; and from this he was restrained by his exhausted constitution. To his brother, the Viscount, who was frequently intoxicated, the Marquis one day said, "How can you, brother, so expose yourself?" "What (replied the Viscount)! how insatiable are you? Nature has given you every vice; and having left me only this one, you grudge it me!"

MISTRAL, the name of a wind, which is mentioned in almost every account that we have of Provence, and which is remarkable for blowing almost the whole year from north west or west-north-west, in a climate where the wind should be variable. It is said to contribute to the salubrity of the air, by dispersing the exhalations of the marshes and stagnant waters, so common in the south of Languedoc and Provence; but at times it is also very injurious, or at least very troublesome. It is not, however, on either of these accounts that it is introduced into this Work, but for the sake of the causes assigned by Saussure for its constancy, which may be applied to other winds that nearly resemble it; and which he found might be reduced to three.

"The first and most effectual cause (he says) is the situation of the Gulf of Lyons, the banks of which are the principal theatre of its ravages. This Gulf, in fact, is situated at the bottom of a funnel, formed by the Alps and Pyrenees. All the winds blowing from any point between west and north, are forced by these mountains to unite in the Gulf. Thus, winds which would not have prevailed but at one extremity of the Gulf, or even much beyond it, are obliged to take this route, after having undergone the repercussion of these mountains; and the middle of the Gulf, instead of the calm which it might have enjoyed, is exposed to the united efforts of two streams of wind, descending in different directions. Hence arise those whirlwinds which seem to characterise the mistral, and appear to have induced the ancients to call it *Circius*, *à turbine ejus ac vertigine*. See *Aul. Gellius*, l. ii. cap. 22.

"The second cause is, the general slope of the grounds, descending from all sides towards the Gulf; which becoming all at once lower and more southerly than the lands extending behind it, is, from these joint circumstances, rendered the hottest point of all the adjacent country: and, as the air on the surface of the earth always tends from the colder to the warmer regions, the Gulf of Lyons is actually the centre towards which the air from all colder points between east and west must press. This cause, then, alone would be productive of winds directed to the Gulf, even if the repercussion of the mountains did not exert its influence.

"Finally, it is well known, that in all gulfs the land-winds blow more forcibly than opposite to plains and promontories, whatever be the situation of those gulfs. I apprehend, indeed, on strict examination (says our author), that this cause is blended with the preceding; but as the fact is generally admitted, and in some cases can be explained only by reasons drawn from the effects of heat, it may not improperly, perhaps, be distinctly mentioned. It is, at least, necessary to suppose, that several causes produce the mistral, in order to understand why, notwithstanding the variableness of the seasons and temperatures, that wind is so singularly constant in Lower Languedoc and Lower Provence. A very remarkable instance of this constancy is recorded by the Abbé Papon, in his *Voyage de Provence*, tome ii. p. 81. He asserts, that during the years 1769 and 1770, the mistral continued for fourteen months successively. But the three causes which I have stated, taken separately, will explain its frequency, and, united, will account for its force."

MIXT ANGLE, or *Figure*, is one contained by both right and curved lines.

Mixt Number, is one that is partly an integer and partly a fraction; as $3\frac{1}{4}$.

Mixt Ratio, or *Proportion*, is when the sum of the antecedent and consequent is compared with the difference of the antecedent and consequent;

$$\text{as if} \begin{cases} 4:3::12:9 \\ a:b::c:d \end{cases}$$

$$\text{then} \begin{cases} 7 \ : \ 1 \ :: \ 21 \ : \ 3 \\ a+b:a-b::c+d:c-d. \end{cases}$$

MOCASSIMAH, in Bengal, revenue settled by a division of the produce.

MOCHULKAH, bond or obligation.

MŒRIS, a lake in EGYPT, occasionally mentioned in that article (*Encycl.*), and generally supposed the production of human art. Of this, however, Mr Brown says it bears no mark "The shape, as far as was distinguishable, seems not inaccurately laid down in D'Anville's map, unless it be, that the end nearest the Nile should run more in a north west and south-east direction. The length may probably be between 30 and 40 miles; the breadth, at the widest part he could gain, was 5000 toises, as taken with a sextant; that is, near-

ly six miles. The utmost possible extent of circuit must of course be 30 leagues. On the north-east and south is a rocky ridge, in every appearance primeval. In short, nothing can present an appearance more unlike the works of men. Several fishermen, in miserable boats, are constantly employed on the lake. The water is brackish, like most bodies of water under the same circumstances. It is, in the language of the country, *Birket el-kerun*, probably from its extremities bearing some resemblance to horns.

MOFUSSEL, a relative term, signifying the subordinate lands or districts, opposed to Sudder, which is the head.

MOHACZ, Mohatz, or *Mohqz*, a town in the Lower Hungary, upon the Danube, between the river Sarwiza to the north, and the Drave to the south; four German miles from either, six from Esseck to the north, and nine from Colocoa to the south. This otherwise small place is memorable for two great battles here fought; the first between Lewis king of Hungary and Solyman the Magnificent, in 1526: in which that unfortunate Prince Lewis (being about 20 years old), with 25,000 men, fought 300,000 Turks; when, being overpowered by numbers, 22,000 of the Christian army were slain upon the place; 5000 waggons, eighty great cannon, 600 small ones, with all their tents and baggage, were taken by the victors; and the King, in his flight over the brook Curass, fell into a quagmire, and was swallowed up. After which, Solyman took and slew 200,000 Hungarians, and got such a footing in that kingdom, that he could never be expelled. This fatal battle was fought October 29. The second, in some part, retrieves the loss and infamy of the former. The Duke of Loraine being sent by the Emperor, with express orders to pass the Drave and take Esseck, his highness, July 10, 1687, with great difficulty passed that river, then extremely swelled with rains; but finding the Prime Visier encamped at Esseck, with an army of 100,000 men, so strongly, that it was not possible to attack him in that post without the ruin of the Christian army, he retreated, and repassed it the 23d of the same month; where, upon the 29th, the Prime Visier passed that river at Esseck; and upon August 12th, there followed a bloody fight, in which the Turks lost 100 pieces of cannon, 12 mortars, all their ammunition, provisions, tents, baggage, and treasure, and about 8000 men upon the place of battle, besides what were drowned in passing the river, which could never be known. After which victory, General Dunewalt, September 30th, found Esseck totally deserted by the Turks, and took possession of it.

MOHER, in Bengal, a gold coin, worth about 33 shillings.

MOHERIR, a writer of accounts.

MOINEAU, a flat bastion raised before a curtin when it is too long, and the bastions of the angles too remote to be able to defend one another. Sometimes the moineau is joined to the curtin, and sometimes it is divided from it by a moat. Here musquetry are placed to fire each way.

MOLE (See Talpa, *Encycl.*), is an animal exceedingly troublesome, both to gardeners and farmers; and there are persons who contrive to make a livelihood by the trade of *mole-catching*. These men, it is well known, are generally quacks and cheats; and the secrets which they sell for extirpating those destructive animals are of very little avail. Even poison seldom produces any considerable effect; because the mole, while it does not drink, lives only on roots and worms. Under the word Mole (*Encycl.*), some directions will be found for clearing fields of this destructive animal; but the following are perhaps preferable, as they seem to have been the result of much experience: Mole.

Immediately at day break, it will be necessary to make a tour round the garden or meadow, from which it is wished to extirpate the moles; for at that time they will be all found at work, as may be seen by the hills newly thrown up. If the person is then close to the hill, he must proceed as the gardeners do, and turn up with a stroke of the spade the hill together with the digger. The passage is then cut through before the animal is aware of the attack; and therefore it has not power to escape. If the mole-hill be fresh, even though the animal may not be throwing up earth, the person ought not to lose his time in waiting, but should immediately proceed to the operation above mentioned.

If you find a fresh hill standing by itself, which seems to shew by its situation that it has no communication with any other, which is always the case when the mole has worked from the surface downwards in endeavouring to procure a more convenient habitation, after the hill has been turned up with the spade, a bucket of water should be poured over the mouth of the passage. By these means the animal, which is at no great distance, will be obliged to come forth, and may be [illegible] caught with the hand.

You may discover also whether a hill has any communication with another, if you apply your ear to it, and then cough or make a loud noise. If it has no communication with the neighbouring hills, you will hear the terrified animal make a noise by its motion. It will then be impossible for it to escape; and you may either pour water into the hole, or turn up the hill with a spade, until the mole is found; for, in general, it never goes deeper into the earth than from fifteen to eighteen inches.

When any of the beds in a garden have been newly watered, the mole, attracted by the coolness and moisture, readily repairs thither, and takes up its residence in them, making a passage at the depth of scarcely an inch below the surface. In that case it may easily be caught. When you see it at work, you need only tread behind the animal with your feet on the passage to prevent its retreat, and then turn up the hill with a spade; by which means you will be sure to catch it.

When you dig after it with a spade, the animal forces its way downwards into the earth in a perpendicular direction, in order that it may the better escape the threatened danger. In that case it will not be necessary to dig long, but to pour water over the place, which will soon make the animal return upwards.

People, in general, are not aware of the great mischief occasioned in fields and gardens by these animals. We are, however, informed by Buffon, that in the year 1740 he planted fifteen or sixteen acres of land with acorns, and that the greater part of them were in a little time carried away by the moles to their subterranean retreats. In many of these there were found half a bushel, and in others a bushel. Buffon, after this circumstance, caused a great number of iron traps to be

Moments, Mongearts. constructed; by which, in less than three weeks, he [illegible] 1300. To this instance of the devastation occasioned by these animals, we may add the following: In the year 1742 they were so numerous in some parts of Holland, that one farmer alone caught between five and six thousand of them. The destruction occasioned by these animals is, however, no new phenomenon. We are informed by history, that the inhabitants of the island of Tenedos, the Trojans, and the Æolians, were infested by them in the earliest ages. For this reason a temple was erected to Apollo Smynthius, the destroyer of moles. See *Oeconomische Hefte*, Vol. VII. Part 5. and Vol IX. Part 4; or *Phil. Magazine*, N° 5.

MOMENTS, in the new doctrine of infinites, denote the indefinitely small parts of quantity; or they are the same with what are otherwise called infinitesimals and differences, or increments and decrements: being the momentary increments or decrements of quantity considered as in a continual flux.

Moments are the generative principles of magnitude; they have no determined magnitude of their own, but are only inceptive of magnitude.

Hence, as it is the same thing if, instead of these moments, the velocities of their increases and decreases be made use of, or the finite quantities that are proportional to such velocities; the method of proceeding which considers the motions, changes, or fluxions of quantities, is denominated by Sir Isaac Newton, the *method of fluxions*.

Leibnitz, and most foreigners, considering these infinitely small parts, or infinitesimals, as the differences of two quantities, and thence endeavouring to find the differences of quantities, *i. e.* some moments, or quantities indefinitely small, which taken an infinite number of times shall equal given quantities, call these moments differences; and the method of procedure, the differential calculus.

MONGEARTS, one of the tribes of wandering Arabs which inhabit the SAHARA, or Great Desert of Africa. Their time is wholly occupied by tending their cattle; and because they are little skilled in the use of arms, *Mongeart* is a term of contempt among the people by whom they are surrounded. Their country, with its produce, will be described under the title SAHARA in this *Supplement*; it is the business of this article merely to exhibit the manners of the people.

They are all Mahometans, and offer up prayers three times a day, sometimes oftener; but having no mosques, these prayers are never pronounced in public, except when the horde is visited by a priest, who seldom comes but upon account of the childrens education. Then all the Arabs assemble at the hour of prayer, place themselves in a line, turn to the east, and, wanting water in the desert, rub their face and arms with sand; while the priest recites aloud the general prayer. It is the same as that which is rehearsed by the public crier in the mosques in civilized countries.

The priests are employed in travelling about the country to instruct the children. There is nothing like force in their education. The little boys meet in the morning of their own accord, at the place of instruction, which is to them a place of recreation. They go there with a small board inscribed with the Arabic characters, and a few maxims of the Koran. The oldest, and the best informed, receive their lessons directly from the priests, and afterwards communicate them to their fellows. They are never corrected; because it would be a crime to beat a child, who, according to the received notions, has not sufficient reason to distinguish good from evil. This lenity extends even to the children of Christians, though in a state of slavery. They are treated in all respects like the children of Arabs; and the man who should be rash enough to strike one of them, would endanger his life. Very different is their treatment of Negro children; who may indeed join in all the amusements of the young Arabs, and even attend the public schools; but if they be guilty of a fault, they are severely punished.

When the child of a Mongeart becomes tired of the places of public instruction, he quits them at pleasure, and, without feeling constraint, or hearing reproach, goes and employs himself in tending his father's flocks: and accordingly there are very few among them who can read. Those who persevere in the study of the Koran are made priests, after having past an examination before the learned elders, and enjoy the greatest public consideration. They have no need of cattle; for those of the nation being theirs, they find their subsistence everywhere.

It is generally at seven or eight years of age that children undergo the painful operation of circumcision. Their head is also shaved, nothing being left but four locks of hair; one of which is cut off in a meeting of the family, at each remarkable action performed by the child. If, at the age of 12 or 13, he kill a wild boar, or other beast of prey, that should fall upon his flock, he loses one of his locks. If, in the passage of a river, a camel be carried away by the stream, and he save it by swimming to its assistance, another is cut off. If he kill a lion, a tiger, or a warrior of an hostile nation, in a surprise or an attack, he is considered as a man, and his head is entirely shaved.

Different from the other Arabs their neighbours, and indeed from the Mahometans in general, the Mongearts trouble no man on account of his religion. The only one which they do not tolerate is the Jewish; and were a Jew to enter their territory, and have the misfortune to be taken, he would certainly be burnt alive.

According to M. Saugnier, the women are much more respected among the Mongearts than among the neighbouring nations; but the evidences which he gives of that respect are very extraordinary.

When a Mongeart is desirous of undertaking the care of a family, he pitches upon the girl that pleases him the most, and asks her of her father without further formality; nor can the latter refuse her, unless the man who pretends to her hand have done something contrary to the laws of the nation. The girl is conducted by her parents to the tent of her future husband, where there is always an abundant repast prepared for the ceremony. Presents are made to the father; but if the son in law be poor, his wife's family assist him, and furnish him with the means of increasing his flocks; if, on the contrary, he be rich, and the father poor, he supports the whole family in his own tent. The employment of the wife, thus married, is to prepare the food; to spin the goats and camels hair, of which the tents are made; to milk the cattle; to pick up the necessary supply of wood for the night; and when the hour of repast is come, to wait upon her husband. She

then

Mongeart. then eats by herself what has been left by him and his male slaves. She is, indeed, in no great danger of having a rival brought into the family; for though polygamy be allowed by his religion, the poverty of the Mongeart generally prevents him from taking a plurality of wives. She is, however, liable to be divorced at will when she does not bear boys; but if she have the good fortune to have one or more male children, her husband's regard for her is inconceivable. She has no longer a divorce to fear, has an absolute authority in the tent, and passes her whole time in conversation, sleep, or dancing, as she thinks fit. The captive negresses do all her work, and are no longer assisted in their labour by the Arab's wife, who treats them, on the contrary, with the greatest harshness and arrogance.

When a woman is not agreeable to her husband, or when he is disagreeable to her, they have it in their power to part. The formality in this case consists in the wife's retiring to her parents. If the husband be attached to her, he goes thither in quest of her; but if she persist in refusing to return, she is free, and at liberty to marry another. If, however, she have had a child, especially a boy, she has not the same privilege; in that case, if her retreat should last more than eight days, it might be punished with death.

When a man beats his wife, it is a sure sign that he is sincerely attached to her, and that he does not mean to part with her; if he content himself with reproaches, the wife thinks herself despised, and infallibly retires to her parents. Hence it is, that in the most trifling disputes the women are cruelly beaten: they prefer it to the complaints that the husband might make to their parents; this proof being the most certain one of a man's fondness for his wife. When a girl marries, she makes up her mind to such treatment, deeming it much more supportable than the humiliations she would otherwise experience from her family, in consequence of her husband's complaints.

The conjugal fidelity of the Mongeart women is incorruptible. Differing in their opinions from many other Mahometans, they believe themselves immortal like the men; but they do not flatter themselves with the possibility of happiness in the other world, unless they shall have been faithful to their husbands in this. Women, who have been false to their husband's bed, will be doomed, they think, to eternal slavery to the more virtuous part of their sex, without ever partaking, in the smallest degree, of their bliss.

Mongeart women often visit one another; and on these occasions, the honour consists in letting the female who comes to see her friend or relation do all the work of the tent. The visitor assumes the management of every thing, dresses the victuals, churns the butter, and keeps herself continually employed; while her friend entertains her with an account of the different affairs of the family or nation. The heartiness of the welcome is measured by the extent of the work submitted to the guest, who generally prepares double the usual quantity of food; so that the Arab is obliged to invite his neighbours to partake of the repast. The slaves are always pleased with these entertainments, a larger portion then coming to their lot. It is the business of the visitor to do the honours; nor will she suffer any body about her to remain dissatisfied.

The laws of hospitality are observed among the Mongearts as among all the wandering Arabs. Indeed they are carried to such a length, that were a man to enter the tent of him whom he had wounded, or even killed, he would there meet with a sacred and inviolable asylum, although surrounded by those who must naturally desire his ruin. The tent of the chief is always that to which strangers, upon their arrival in the horde, are directed. But the chief could not entertain, at his own expence, all the strangers that happen to pass; and therefore every tent in the horde is obliged to furnish him with two pounds of ground barley *per* week, to enable him to maintain the ancient hospitality.

The chiefs of hordes are always the eldest of their families. The difference of wealth is not considered; the chief often having several individuals at his horde richer than himself, who nevertheless obey him in every particular. He is, properly speaking, their king; examines their difference with the old men, and judges without appeal. As to himself, he cannot be tried but by the chiefs of several hordes assembled. It is his business to determine the spots where the tents are to be pitched, the moment of departure, and the place where the caravan is to stop. If the pasturage do not suffice for the herds of all the horde, it divides, and the chief assigns the ground for the different encampments. They are very often composed of no more than seven or eight tents, according to the quality of the ground they meet with. The tent of the chief is always the largest and most lofty, and is placed in the centre of the divisions. When it is determined upon to quit an encampment, which never happens till the pasture is exhausted, the chief sets off to choose another spot. In these removals the women alone do all the work. Early in the morning they fold up the tent, and load every thing upon the camels backs; they then move slowly on, that the cattle may have time to feed upon the way.

Great respect is paid by the Mongearts to all old men, who enjoy the same prerogatives as the priests, and such Arabs as have visited the tomb of Mahomet at Mecca. Together with the chief they are the judges of the horde, and take cognizance of all offences, the pain of death being the only punishment which they cannot decree. An assembly of several chiefs is the only tribunal which can inflict capital punishment; but as the accused has generally a number of friends, it seldom happens that he is capitally convicted.

A war between two Mongeart tribes seldom happens, and is never bloody; but the different families destroy one another fast enough in their intestine broils. They are all thieves; and indeed theft is a crime only in the day-time, being authorised by law during the night, in order to compel them to take care of their cattle. Could they find redress when robbed by night, they would be less vigilant; and their herds and flocks would be more exposed to the wild beasts that over run their country; but being obliged to be on their guard even against their nearest neighbours, they are always ready to repel both the lion and the tiger. Theft, even in the day-time, is so far from being punished, unless detected at the instant of commission, that when any thing is stolen unperceived, it becomes the lawful property of the thief. In vain would the rightful owner recognize it in his neighbour's tent, he cannot reclaim it; it ceases to be his from the moment he has been negligent in its care. Hence arises this peoples inclination for rapine:

Mongearts they do not think they commit a crime, and only follow, in this regard, a custom allowed by their laws.

When an Arab is going to market, or on his return from thence, if he do not take the greatest care to keep his journey a secret, he is often attacked. Neighbouring Arabs are desirous of profiting by his industry; and as there are no persons in the country appointed to apprehend robbers, the hope of booty spurs them on to the attack. That they may have nothing to fear, they lie in wait, when the night is coming on, for him whom they mean to pillage. Their intention is never to kill; they only endeavour to surprize, to disarm, and to make themselves masters of every thing that comes in their way. But it sometimes happens, that the man they intend to plunder, being acquainted with the customs of his country, keeps an attentive ear, stands on his guard, fires upon his assailants at the first motion he observe and then fights desperately with his dagger. The report of the musket almost always brings out the neighbouring Arabs, who, in virtue of the laws of hospitality, take the defence of the weaker side. They run up well armed; and then woe to the aggressors, if they do not save themselves by a speedy flight.

The flocks and herds of the Mongearts are composed of nothing but sheep, goats, and camels; all animals patient of thirst. Horses are very scarce in these cantons, none but the possessors of numerous herds being able to keep them; because, for want of water, it is necessary to have milk in sufficient abundance to give it them to drink. Great care is taken to preserve the camel's urine, both to mix with milk, and to wash the different vessels in which they put their food. Detestable as is this mixture of milk and urine, they are often reduced to the use of it; hunger and thirst give a relish to every thing.

The only workmen useful to this nation are blacksmiths or goldsmiths, as they may be called indifferently. The Mongearts not being sufficiently laborious to apply themselves to such occupations, these workmen come from Bilidulgerid, and disperse themselves all over the different parts of the desert. Wherever there are tents they are sure to find work. They are fed for nothing, and receive besides the hire for their labour. They make trinkets for the women, such as ear-rings and bracelets, &c. mend the broken vessels, by rivetting them, and clean the arms. They are generally paid in skins, goats and camels hair, or ostrich feathers, according to their agreement. Those who have silver pay them a tenth part of its weight for any thing wrought out of that metal. On their return they sell what they have earned; four or five excursions at most enabling them to live afterwards at their ease in their own country.

The Mongearts always carry a leathern bag, suspended from their neck, in which they put their tinder, their pipe, and their tobacco. Their daggers are elegant; the hilt is always black, and inlaid with ivory; the blade is crooked, and sharp on either side; the sheath is of brass on one side, and of silver on the other, and of very tolerable workmanship. They wear sabres when they can get them, and prefer those of Spanish make. Their muskets are always highly ornamented; the stock is very small, and inlaid on every side with ivory, and the barrel embossed with brass or silver, according to the opulence of the owner. There is a spring to the lock, covering the priming, to prevent the piece from going off, contrary to the intention of him who carries it. The poor, who do not possess muskets, wear daggers, made like the Flemish knives, with leathern sheaths. They arm themselves also with a thick stick, to the end of which they fix a kind of iron wedge. This weapon is exceedingly dangerous at close quarters. Others carry *zagays*, or slender javelins. In a word, the principal riches of an Arab, and his highest gratifications, are a handsome musket and a good dagger. He prefers them to neatness of apparel; for as to dress, it is indifferent to him whether he be clothed in Guinea blues, woollen stuffs, or goats skins. Their arms being their principal ornament, they take particular care to put the muskets in leathern bags, by way of keeping them in good order, and preserving them from the rust.

Mongearts All the riches of the Mongearts consist in their herds; and accordingly they take the greatest care to preserve them. If a beast be sick, every thing is done to cure it; no care is spared; it is even treated with more attention than a man: but when it evidently appears that there is no hope of saving its life, they kill and eat it. If it be a camel, the neighbours are called in to partake of the repast; if a goat, the inhabitants of the tent suffice for its consumption. An animal that dies without shedding blood is unclean. Its throat must be cut; the person who kills it turning to the east, and pronouncing beforehand the first words of the general prayer. An animal killed by a wild boar is unclean; nor is it eaten although its blood has been shed, because the wild boar is itself an unclean beast. That species is so numerous in the desart, that they do more mischief than all the other wild beasts together. The Arabs kill as many as they can; but never taste their flesh.

Whatever losses an Arab may meet with, he is never heard to complain; he rises superior to poverty, supports hunger, thirst, and fatigue, with patience, and his courage is proof against every event. God will have it so, says he: he employs, however, every means in his power to avert misfortune; and often exposes himself to the greatest dangers to procure matters of no real utility.

When a father of a family dies, all the effects in his tent are seized upon by the eldest son present at his decease. Gold, silver, trinkets, every thing disappears; and the absent children have only an equal share in the division of the cattle and the slaves. The girls are entirely excluded from all participation, and take up their residence with their eldest brother. If the deceased leave children in helpless infancy, the mother takes them with her to her sister's, if she have a sister married; if not, to her own maternal roof. The dead man's possessions, however, are not lost; the chief of the horde takes care of them, and delivers them in equal portions to the heirs, as soon as they are old enough to manage their own property. If an Arab die without male children, his wife returns to her relations, and his brother inherits his effects.

The Mongearts have a rooted abhorrence of the Spaniards, and never fail to massacre every man of that nation who is so unfortunate as to be shipwrecked on their coasts, while they reserve the women for sale at Morocco. The reason of this hatred is, that the inhabitants of the Canaries make frequent descents on the Mongeart coasts, and carry off men, women, cattle, and

every thing that they meet with ; and these people, being ignorant of the fate of their countrymen, retaliate by death on all Spaniards that fall into their hands, whilst they treat the British and French as well as they can.

MONNIER (Peter Charles Le), was born at Paris on the 20th of November 1715. The profession of his father, or the rank which he held in society, we have not learned ; and we are equally ignorant of the mode in which he educated his son. All that we know is, that young Monnier, from his earliest years, devoted himself to the study of astronomy ; and that, when only sixteen years of age, he made his first observation, viz. of the opposition of Saturn. At the age of twenty he was nominated a member of the Royal Academy of Sciences at Paris. In the year 1735 he accompanied Maupertuis in the celebrated expedition to Lapland, to measure a degree of latitude. In 1748 he went to Scotland with Lord Macclesfield, to observe the annular eclipse of the sun, which was most visible in that country ; and he was the first astronomer who had the pleasure to measure the diameter of the moon on the disk of the sun.

Louis XV. it is well known, was extremely fond of astronomy, and greatly honoured its professors : he loved and esteemed Le Monnier. I have seen the king himself (says Lalande) come out of his cabinet, and look around for Le Monnier ; and when his younger brother was presented to him on his appointment to the office of first physician, his Majesty was pleased to wish him the merit and reputation of his brother the astronomer. All the remarkable celestial phenomena were always observed by the king, in company with Le Monnier. Thus he observed with him, at his chateau of St Hubert, the two celebrated transits of Venus thro' the disk of the sun in the years 1761 and 1769; as appears from the Memoirs of the Royal Parisian Academy of Sciences. It well deserves to be here recorded in what manner the king behaved during these important observations, and how little he disturbed his astronomers (the celebrated La Condamine being likewise permitted to observe the transit in his presence) in this occupation ; the proper time for which, if permitted to pass by, could not be recalled. Le Monnier relates in his Dissertation, that "his Majesty perceiving that we judged the last contacts to be of the greatest importance, a profound silence at that moment reigned around us." At the transit of Venus in 1769, the king allowed the Marquis de Chabert, an intelligent and expert naval officer, who was just returned from a literary voyage to the Levant, to assist at the observation. In a court like that of Louis XV. so scrupulously observant of etiquette, these will be allowed to have been most distinguished marks of honour, and of royal favour and condescension.

In the year 1750, Le Monnier was ordered to draw a meridian at the royal Chateau of Bellevue, where the king frequently made observations. The monarch on this occasion rewarded him with a present of 15,000 livres ; but Le Monnier applied this sum of money likewise in a manner that redounded to the honour of his munificent sovereign and of his country, by procuring new and accurate instruments, with which he afterwards made his best and most remarkable observations. In 1742, the king gave him in Paris *Reu de la Poste*, a beautiful free dwelling, where, till the breaking out of the revolution, he resided, and pursued his astronomical labours, and where his instruments in part yet remain. Some of them the present French government has, at the instance of Lalande, purchased for the National Observatory. In 1751, the king presented him with a block of marble eight feet in height, six feet in breadth, and fifteen inches in thickness, to be used for fixing his mural quadrant of five feet. This marble wall, together with the instruments appended to it, turns on a large brass bell and socket, by which the quadrant may be directed from south to north : thus serving to rectify the large mural quadrant of eight feet, which is immoveably made fast to a wall towards the south.

With these quadrants Le Monnier observed, for the long period of forty years, the moon with unwearied perseverance at all hours of the night. It is requisite, to be a diligent astronomer, to be able to conceive to what numberless inconveniences the philosopher is exposed during an uninterrupted series of lunar observations. As the moon during a revolution may pass through the meridian at all hours of the day or night the astronomer who, day after day, prosecutes such observations, must be prepared at all, even the most inconvenient, hours, and sacrifice to them his sleep and all his enjoyments. How secluded from all the pleasures of social intercourse, and how fatiguing such a mode of life is, those astronomers, indeed, know not who then only set their pendulum clocks in motion, when some of the eclipses of the sun, moon, or of the satellites of Jupiter, are to be viewed. At this time, and in the present state of the science, these are just the most insignificant observations; and an able astronomer, well supplied with accurate instruments, may *every day*, if he take into his view the whole of his profession, make more important and more necessary observations

Le Monnier was Lalande's preceptor, and worthy of such a scholar ; and he promoted his studies by his advice, and by every other means in his power. Le Monnier's penetrating mind, indeed, presaged in young Lalande, then only sixteen years old, what in the sequel has been so splendidly confirmed. In his twentieth year, he became, on the recommendation of his preceptor, a member of the Royal Academy : and in 1752 he was proposed by him as the fittest person to be sent to Berlin, to make with La Caille's, who had been sent to the Cape of Good Hope, correspondent observations, for the purpose of determining the parallaxes of the moon, then but imperfectly known. Le Monnier lent his pupil for this expedition his mural quadrant of five feet. His zeal for astronomy knew no bounds. For this reason Lalande, in his *Notice des Travaux du C. Le Monnier*, says of himself : "*Je suis moi-meme le principal resultat de son zele pour l'astronomie.*"

Le Monnier was naturally of a very irritable temper : as ardently as he loved his friends, as easily could he be offended ; and his hatred was then implacable. Lalande, as he himself expresses it, had the misfortune to incur the displeasure of his beloved preceptor ; and he never after could regain his favour. But Lalande's gratitude and respect for him always continued undiminished, and were on every occasion with unremitting constancy publicly declared : patiently he endured from him undeserved ill treatment ; so much did he love and

esteem

Mon

efteem his inftructor and mafter to the day of his death. "I have not ceafed to exclaim (write. Lalande), as Diogenes exclaimed to his mafter Antifthenes, You cannot find a ftick ftrong enough to drive me away from you!"

What a noble trait in the character of Lalande, who in 1707 wrote likewife an eulogium on Le Monnier in the ftyle of a grateful pupil. penetrated with fentiments of profound veneration and efteem for his beloved mafter; but Le Monnier would not read it. This is not the place to give a circumftantial account of this intricate quarrel; we fhall only further remark, that Lalande was the warm friend and admirer of the no lefs eminent aftronomer La Caille, whom Le Monnier mortally hated. An intimate friendfhip likewife fubfifted between Le Monnier and D'Alembert; but Lalande had no friendly intercourfe with the latter.

Among the fcholars of Le Monnier may likewife be reckoned Henwart, the celebrated geometrician and profeffor of mathematics at Utrecht; who, in a letter to Von Zach, aftronomer to the Duke of Saxe Gotha, dated the 26th of May 1797, fays, "Le Monnier is a penetrating and philofophical aftronomer: I learned much from him in Paris; though I lodged with the late De l'Ifle, where I frequently made obfervations in company with Meffier. Le Monnier was the friend of D'Alembert; and confequently an oppofer of Lalande"

This great man, who had, for fome years, ceafed to exift either for the fcience of aftronomy, or for the comfort of his friends, died at Lizeaux, in the province of Normandy, in 1799, aged 84 years. He left behind him fome valuable manufcripts, and a number of good obfervations; with refpect to which he had always been very whimfical, and of which in his latter years he never would publifh any thing. He had by him a feries of lunar obfervations, and a multitude of obfervations of the ftars, for a catalogue of the ftars, which he had announced fo early as the year 1741; among which was twice to be found the new planet Uranus: (See *Lalande's Aftronomie, Tables*, p. 188, (A). The more he was requefted to communicate his obfervations, the more obftinate he became; he even threatened to deftroy them. At the breaking out of the revolution, Lalande was greatly alarmed for the fafety of thefe papers; he wifhed to preferve them from deftruction, and made an attempt to get them into his poffeffion; but all his endeavours were in vain. He was only able to learn, that Le Monnier had hidden them under the roof of his houfe. Le Monnier having been firft feized with a fit of the apoplexy fo early as the 10th of November 1791, Lalande apprehended, left, if no one except himfelf fhould know where he had hidden his papers, the infirm old man might perhaps have himfelf forgot it. He hopes, however, that La Grange, who married his fecond daughter, may have fome information concerning them. Le Monnier left behind him no fon.

Monomial, Monfelemines.

MONOMIAL, in algebra, is a fimple or fingle nomial, confifting of only one term; as a or $a x$, or $a^2 b x^2$, &c.

MONOTRIGLYPH, a term in architecture, denoting the fpace of one triglyph between two pilafters, or two columns.

MONSELEMINES, are a people which inhabit that part of BILEDULGERID (fee *Encycl.*) that borders on the territories of the Emperor of Morocco. They are a mixed race, being defcended from the ancient Arabs and fugitive Moors; and they occupy a fpace of land. of which the limits are indicated by lofty columns placed at intervals towards the defart. Their territory extends from about 30 leagues beyond Cape Non, to the diftance of 20 leagues from St Croix or Agader. Though of different qualities, it is, for the moft part, very fertile, and produces the neceffaries of life with little cultivation. The plains are watered by an infinite number of ftreams, and abound with palm, date, fig, and almond trees. The gardens produce excellent grapes, which are dried by the Arabs, and converted into brandy by the Jews. Great quantities of oil, wax, and tobacco, appear in the public markets.

More induftrious and more laborious than their neighbours, the Monfelemine nation cultivates the earth. The chiefs of families choofe the ground moft fit for cultivation. Its furface is turned flightly over with a kind of hoe, and then the feed is fown upon it: the field is furrounded with bufhes, to mark the fpot, and to preferve it from the cattle of the wandering Arabs. When the crop is ripe, which is generally at the end of Auguft, three months after the fowing of the feed, it is cut about fix inches from the ear, and formed into little bundles; during which time every one labours without intermiffion from morning to night. The corn is brought before the tent, thrafhed, winnowed, and placed in the magazines. When the harveft is over, they fet fire to the long ftubble, and abandon the field for two or three years. Their magazines are large holes in the earth, formed like the fruftum of a cone, the infides of which are hardened by burning wood in them, before the half winnowed corn be depofited. When filled with corn, they are covered with planks placed clofe to each other; over which a layer of earth is laid level with the foil, to prevent it from being difcovered by enemies. In thefe magazines every one fhares in proportion to the number of men he employed in the common labour.

The inhabitants of the plains remain by the cultivated fields in feed time, and return at the time of harveft. During the intervals they wander in all directions with their cattle, taking only neceffaries along with them, and having recourfe to the magazines when they require

(A) Such is the French and German account of his difcovery of this planet; but our readers have been very inattentive, if they have not perceived, in various articles of this Work, complete proofs of the plagiarifm of our neighbours on the Continent, from the celebrated philofophers and divines of England. As it is extremely probable that, half a century hence, a claim may be put in for Le Monnier's difcovery of the Georgium Sidus (*Uranus*), fimilar to that which in 1757 the editor of Abbe St Real's works put in for that Abbé being the author of Leflie's *Short Method with the Deifts* (fee LESLEY in this *Suppl.*), we think it our duty to declare, that in 1800 there was no evidence whatever on which to found that claim, and that the difcovery was then univerfally allowed to have been made by Herfchel.

Monfele mines.

quire a fupply. The more opulent people, and the artizans who are engaged in fedentary occupations, dwell in towns, which are all fituated upon the declivity of hills. Their houfes are built of ftone and earth according to the Moorifh conftruction, low and covered with floping terraces; yet they are fo much injured by the heavy rains which prevail for three months of the year, as to be rendered uninhabitable in 15 or 20 years. Thofe who refide in towns are generally weavers, fhoemakers, goldfmiths, potters, &c and have no cattle; but the more opulent perfons have flocks and herds of cows, horfes, camels, fheep, goats, befides poultry, which are kept by their flaves at a diftance from the towns. In the towns they take two meals a day; one at ten o'clock, and the other at the fetting of the fun, though the inhabitants of the country only eat in the evening. In the towns they fleep in mats upon the floors of their apartments, and make ufe of linen; but the inhabitants of the country fleep upon terraces in the open air. The paftoral families of the country practife hofpitality like thofe of the defart, and make the traveller pay nothing for his entertainment. In the towns this practice is impoffible, as the concourfe of ftrangers, efpecially on market-days, would foon impoverifh the inhabitants. In this manner hofpitality is always extinguifhed among a trading and commercial people. It is only where the fuperfluity of commodities runs neceffarily to wafte, that it is ever practifed in a great extent; but where every commodity can find a market, every kind of property acquires a definite value, and will be preferved with the fame care as money.

By M. Saugnier the government of the Monfelemines is faid to be republican; but he writes inconfiftently about it In one place, he fays that they choofe their chiefs annually; in another, that in the time of war they choofe from the natives or fugitive Moors indifcriminately, chiefs, whofe authority lafts no longer than the campaign, during which it is abfolute; and he afterwards reprefents their goverment as a kind of theocracy, during war as well as peace. But we muft follow him in his detail, as it has been well arranged in a late anonymous publication, entitled, *An Hiftorical Sketch of Difcoveries in Africa*.

At the end of each campaign, he fays the chief gives an account of his actions to the affembled aged men, and is rewarded or punifhed according to his conduct; after which his fucceffor is appointed, and he ferves in the army he commanded as an undiftinguifhed individual. The country is populous, and would be ftill more fo, were it not for the continual wars which its inhabitants are obliged to fupport againft the Emperor of Morocco. The liberty they enjoy imparts energy and courage to their character, and renders their arms invincible to the Moors. They confider it as the moft invaluable poffeffion, and defend it to the laft extremity. The nature of the country, furrounded on every fide by fteep and arid mountains, contributes to fruftrate the efforts of their enemies. The Monfelemine, richer than the fubject of Morocco, is always well clothed and armed. He pays no tribute, enjoys the fruit of his labour and commerce, and, as no contributions are requifite for the charges of the ftate, whatever he acquires is his own. The fugitive Moors are never armed, except when they go to battle; but the natives go continually armed, whether they refide in the country, refort to the markets, attend the affemblies of the nation, or pay vifits.

As the Monfelemine territory is the retreat of the rich Moors, who wifh to fly from the tyranny of the Emperor of Morocco, they are too well acquainted with the Moorifh cuftoms to be furprifed by that prince. No fooner does a Moorifh army take the field, than the inhabitants of the country cantons mount their horfes, and occupy the paffes of the mountains; while the women and flaves, efcorted by a fufficient number of warriors, retire to the interior parts of the country, or, if they be hard preffed, to the defart. Among the paftoral tribes there are many that addict themfelves entirely to arms, and ferve as cavalry in the time of war. During peace they efcort caravans, or exercife themfelves in military evolutions, and the management of their horfes. Being almoft always on horfeback, and wearing no boots, they have a callous lump on that part of the leg that comes in contact with the iron of the ftirrup. Their horfes, which they break in an admirable manner, are the beft in the world: as they are treated with great care by their mafters, they know them, and are obedient to their voice, and will admit no ftranger to mount them.

The Monfelemines derive their origin and name from Mofeilama, a contemporary of Mahomet; and, in their love of liberty, as well as in many of their cuftoms, refemble the Arabs of remoter times. They refpect the prophet like other Mahometans; but neither believe that he was infallible, nor that his defcendants are all infpired by God, nor that their will fhould be a law, nor that fuch faith is neceffary in order to be a good Mahometan. Their priefts are refpected, and in old age generally become the civil judges of the nation; but the influence of the high prieft is almoft defpotic. Though he has no troops, he may command the nation; and war and peace depend upon his will. Though he has no property, every thing is at his difpofal: he requires nothing from any one, and yet all are inclined to give. He adminifters juftice according to the opinion of his counfel, without pretending to be infpired by the prophet.

On Friday the Monfelemines affemble in their mofques to pray: this is likewife the day of their principal market, when their merchandize is expofed to fale in the public fquares, where the old men judge without appeal, when difputes arife. Different from their neighbours of Morocco and Sahara, the Monfelemines never attempt to make profelytes. Their Chriftian flaves are treated with humanity; but they owe this to the avarice of their mafters. Thefe deteft Chriftians, but they love money, and are afraid left ficknefs or death fhould deprive them of the ranfom of the flave, or of the advantage of his labour. Among the inhabitants of the defart, a Chriftian, that adopts the religion of Mahomet, is admitted as a citizen and member of the family, and is prefented with cattle to form an eftablifhment. The Monfelemines pay more attention to the value of their property than the fituation of the infidel. A Chriftian who enters a mofque at Morocco is put to death, or forced to affume the turban. The Monfelemines would turn him civilly out, and content themfelves with impofing the higheft poffible fine. Among the Moors, a Chriftian difcovered in an intrigue with a woman of that nation fuffers death, or fubmits to con-

Monfelemines, Monterey.

conversion; but the Monfelemines prefer money to religion. From them the Christian has nothing to fear: the woman alone is punished, being put into a fack, and thrown into the fea. If a Christian flave among the neighbouring nations defends himfelf againft his mafter, he is punifhed with death; but money faves him among the Monfelemines; he would at moft receive a flight correction.

The Jews are allowed the free exercife of their religion among the Monfelemines, but are treated with the fame indignity as among other Mahometan tribes. A Jew is not permitted to carry arms; and if he fhould make ufe of them againft an Arab, he would be punifhed with death, and probably involve his family in his fate. The Jews inhabit the towns only, where they follow trade and various arts, but are not allowed to cultivate the earth.

Polygamy is permitted, as in other Mahometan countries; but the fituation of the women is more refpectable, and they are not fo much fecluded as among the Moors. They mingle more in fociety, walk at large, and vifit their friends; neither are their apartments fo inviolable. Among the Monfelemines, that degrading picture of humanity is never feen which fometimes occurs in Morocco, a woman drawing the plough with an afs, a mule, or fome other beaft of burden. More happy than the women of the Sahara, and treated with greater attention by their hufbands, they are more humane in their difpofitions. Like other Arab women, they ftain the edges of their eyelids black with henna, and paint their faces red and yellow. Their children are brought up with great care, and are not obliged to exhibit proofs of their courage before they can be confidered as men, as is the cuftom in the defart. Avarice is the principal defect in the character of the Monfelemines. They hoard their money with the utmoft care, bury it in the earth, and in many cafes die without difcovering their fecret even to their children. Mifers, fays M. Saugnier, fhould go to that country, where they would learn means of economy; which would fhew them, that, in comparifon with the Monfelemines, they are themfelves perfect prodigals.

The medicinal applications of the Monfelemines, which differ not from thofe of the MONGEARTS and other inhabitants of the defart, are extremely fimple, but appear fufficiently complex from the mummery of the priefts, who are the depofitories of their medical fcience. Flefh wounds are cauterifed with a hot iron, and then covered with herbs dipped in turtles oil and tar. In headachs, a comprefs is applied with fuch violence that the blood ftarts from the forehead. In internal difeafes, the general remedies are regimen, reft, and a few maxims of the Koran myfterioufly applied to the affected parts.

MONTEREY BAY, in North California, was vifited in 1786 by La Peroufe, who places it in 36° 58′ 43″ N. Lat. and 124° 40′ W. Long from Paris. It is formed by New-year Point to the north, and by that of Cyprus to the fouth; has an opening of eight leagues in this direction, and nearly fix of depth to the eaftward, where the land is fandy and low. The fea breaks there as far as the foot of the fandy downs with which the coaft is furrounded, with a roaring which may be heard more than a league off. The lands north and fouth of this bay are high, and covered with trees. Thofe fhips which are defirous of touching there ought to follow the fouth coaft, and after having doubled the Point of Pines, which ftretches to the northward, they get fight of the prefidency, and may come to an anchor in ten fathoms within it, and a little within the land of this point, which fhelters from the winds from the offing. The Spanifh fhips, which propofe to make a long ftay at Monterey, are accuftomed to bring up within one or two cable's lengths of the land, in fix fathoms, and make faft to an anchor, which they bury in the fand of the beach; they have then nothing to fear from the foutherly winds, which are fometimes very ftrong; but, as they blow from the coaft, do not expofe them to any danger. The two French frigates, which our author commanded, found bottom over the whole bay, and anchored four leagues from the land, in 60 fathoms, foft muddy ground; but there is a very heavy fea, and it is only an anchorage fit for a few hours, in waiting for day, or the clearing up of the fog. At full and change of the moon it is high water at half paft one o clock: the tide rifes feven feet; and as this bay is very open, the current in it is nearly imperceptible. It abounds with whales; a genus of fifhes, of which our *fcientific* voyagers knew fo little, that they were furprifed at their fpouting water!

The coafts of Monterey Bey are almoft continually enveloped in fogs, which caufe great difficulty in the approach to them. But, for this circumftance, there would be few more eafy to land upon; there is not any rock concealed under water that extends a cable's length from the fhore; and if the fog be too thick, there is the refource of coming to an anchor, and there waiting for a clear, which will enable you to get a good fight of the Spanifh fettlement, fituated in the angle formed by the fouth and eaft coaft. The fea was covered with pelicans. Thefe birds, it feems, never go farther than five or fix leagues from the land; and navigators, who fhall hereafter meet with them during a fog, may reft affured that they are within that diftance of it.

A lieutenant-colonel, whofe refidence is at Monterey, is governor of the Californias: the extent of his government is more than 800 leagues in circumference, but his real fubjects confift only of 282 cavalry, whofe duty it is to garrifon five fmall forts, and to furnifh detachments of four or five men to each of the 25 miffions, or parifhes, eftablifhed in old and new California. So fmall are the means which are adequate to the reftraining about 50,000 wandering Indians in this vaft part of America, among whom, nearly 10,000 have embraced Chriftianity. Thefe Indians are, in general, fmall and weak (A), and difcover none of that love of liberty and independence which characterifes the northern nations, of whofe arts and induftry they are alfo deftitute. Their colour very nearly approaches that of the negroes whofe hair is not woolly; the hair of thefe people is ftrong, and of great length; they cut it four or five inches from the roots. Several among them have a beard; others, according to the miffionary fathers, have never had any; and this is a queftion which is even undecided

(A) The chief furgeon of the expedition fays they are *ftrong*, but ftupid.

Mongearts. decided in the country. The governor, who had travelled a great way into the interior of theſe lands, and who had paſſed 15 years of his life among the ſavages, aſſured our author, that thoſe who had no beards had plucked them up with bivalve ſhells, that ſerved them as pincers: the preſident of the miſſions, who had reſided an equal length of time in California, maintained the contrary;—it was difficult, therefore, for travellers to decide between them." The difficulty, ſurely, was not great. By their own account, the governor had travelled much farther into the country than the miſſionary; and his report being confirmed by the evidence of their own ſenſes, was intitled to unlimited credit.

Theſe Indians are extremely ſkilful in drawing the bow; they killed, in the preſence of the French, the ſmalleſt birds: it is true, they diſplay an inexpreſſible patience in approaching them; they conceal themſelves, and, as it were, glide along near to the game, ſeldom ſhooting till within 15 paces. Their induſtry in hunting the larger animals is ſtill more admirable. Perouſe ſaw an Indian, with a ſtag's head fixed upon his own, walk on all fours, as if he were browſing the graſs; and he played this pantomime to ſuch perfection, that all the French hunters would have fired at him at 30 paces, had they not been prevented. In this manner they approach herds of ſtags within a very ſmall diſtance, and kill them with a flight of arrows.

Before the Spaniſh ſettlements, the Indians of California cultivated nothing but maize, and almoſt entirely lived by fiſhing and hunting. There is not any country in the world which more abounds in fiſh and game of every deſcription: hares, rabbits, and ſtags are very common there; ſeals and otters are alſo found there in prodigious numbers; but to the northward, and during the winter, they kill a very great number of bears, foxes, wolves, and wild cats. The thickets and plains abound with ſmall grey tufted partridges, which, like thoſe in Europe, live in ſociety, but in large companies of three or four hundred; they are fat, and extremely well flavoured. The trees ſerve as habitations to the moſt delightful birds; and the ornithologiſts of the voyage ſtuffed a great variety of ſparrows, titmice, ſpeckled wood-peckers, and tropic birds. Among the birds of prey are found the white-headed eagle, the great and ſmall falcon, the goſs hawk, the ſparrow hawk, the black vulture, the large owl, and the raven. On the ponds and ſea-ſhore are ſeen the wild duck, the grey and white pelican with yellow tufts, different ſpecies of gulls, cormorants, curlews, ring-plovers, ſmall ſea water hens, and herons; together with the bee eater, which, according to moſt ornithologiſts, is peculiar to the old continent.

The country about Monterey Bay is inexpreſſibly fertile. The crops of maize, barley, corn, and peaſe, cannot be equalled but by thoſe of Chili; our European cultivators can have no conception of a ſimilar fertility; the medium produce of corn is from ſeventy to eighty for one; the extremes ſixty and a hundred. Fruit trees are ſtill very rare there, but the climate is extremely ſuitable to them: it differs a little from that of the ſouthern French provinces. The foreſt trees are, the ſtone-pine, cyprus, evergreen oak, and occidental plane tree. There is no underwood; and a verdant carpet, over which it is very agreeable to walk, covers the ground. There are alſo vaſt ſavannahs, abounding with all ſorts of game.

Perouſe writes with great reſpect of the wiſe and pious conduct of the Spaniſh miſſionaries at Monterey, who ſo faithfully fulfil the purpoſe of their inſtitution. Totally unlike the monks at CONCEPTION in Chili (ſee that article in this *Suppl*), they have left the lazy life of a cloiſter, to give themſelves up to cares, fatigues, and ſolicitudes of every kind. They invited the of the frigates to dine with them at their monaſtery, contiguous to which ſtands the Indian village, conſiſting of about 50 cabins, which ſerve as dwelling-places to 740 perſons of both ſexes, compriſing their children, which compoſe the miſſion of Saint Charles, or of Monterey. Theſe cabins are the moſt miſerable that are to be met with among any people; they are round, ſix feet in diameter, by four in height; ſome ſtakes, of the ſize of an arm, fixed in the earth, and which approach each other in an arch at the top, compoſe the timber work of it; eight or ten bundles of ſtraw, very ill arranged over theſe ſtakes, defend the inhabitants, well or ill, from the rain and wind; and more than half of this cabin remains open when the weather is fine; their only precaution is to have each of them two or three bundles of ſtraw at hand by way of reſerve.

All the exhortations of the miſſionaries have never been able to procure a change of this general architecture of the two Californias. The Indians ſay, that they like plenty of air; that it is convenient to ſet fire to their houſes when they are devoured in them by too great a quantity of fleas; and that they can build another in leſs than two hours. The independent Indians, who as hunters ſo frequently change their places of abode, have a ſtronger motive.

The monks gave the moſt complete information reſpecting the government of this ſpecies of religious community; for no other name can be given to the legiſlation they have eſtabliſhed. They are ſuperiors both in ſpiritual and temporal affairs: the products of the land are entirely entruſted to their adminiſtration. There are ſeven hours allotted to labour in the day, two hours to prayers, and four or five on Sundays and feſtivals, which are altogether dedicated to reſt and divine worſhip. Corporal puniſhments are inflicted on the Indians of both ſexes who neglect pious exerciſes; and ſeveral ſins, the puniſhment of which in Europe is reſerved only to Divine Juſtice, are puniſhed with chains or the ſtocks.

The Indians, as well as the miſſionaries, riſe with the ſun, and go to prayers and maſs, which laſt an hour; and during this time there is cooked in the middle of the ſquare, in three large kettles, barley meal, the grain of which has been roaſted previous to being ground; this ſpecies of boiled food, which the Indians call *atole*, and of which they are very fond, is ſeaſoned neither with ſalt nor butter, and to us would prove a very inſipid meſs. Every cabin ſends to take the portion for all its inhabitants in a veſſel made of bark: there is not the leaſt confuſion or diſorder; and when the coppers are empty, they diſtribute that which ſticks to the bottom to the children who have beſt retained their leſſons of catechiſm. This meal continues three quarters of an hour, after which they all return to their labours; ſome go to plough the earth with oxen, others to dig the garden; in a word, every one is employed in diffe-

Mongearts. rent domeſtic occupations, and always under the ſuperintendance of one or two of the religious.

The women are charged with little elſe but the care of their houſewifery, their children, and roaſting and grinding the ſeveral grains: this laſt operation is very long and laborious, becauſe they have no other means of doing it but by cruſhing the grain in pieces with a cylinder upon a ſtone. M. de Langle, being a witneſs of this operation, made the miſſionaries a preſent of his mill; and a greater ſervice could not have been rendered them, as by theſe means four women would in a day perform the work of a hundred, and time enough will remain to ſpin the wool of their ſheep, and to manufacture coarſe ſtuffs.

At noon the dinner was announced by the bell; the Indians quitted their work, and ſent to fetch their rations in the ſame veſſels as at breakfaſt: but this ſecond meſs was thicker than the firſt; there was mixed in it corn and maize, and peaſe and beans; the Indians name it *pouſſol*. They return again to their labour from two o'clock till four or five; afterwards they attend evening prayers, which continue near an hour, and are followed by a new ration of *atole* like that at breakfaſt. Theſe three diſtributions are ſufficient for the ſubſiſtence of the far greater number of Indians; and this very economical ſoup might perhaps be very profitably adopted in our years of ſcarcity; ſome ſeaſoning would certainly be neceſſary to be added to it, their whole knowledge of cookery conſiſting in being able to roaſt the grain before it is reduced into meal. As the Indian women have no veſſels of earth or metal for this operation, they perform it in large baſkets made of bark, over a little lighted charcoal; they turn theſe veſſels with ſo much rapidity and addreſs, that they effect the ſwelling and burſting of the grain without burning the baſket, though it is made of very combuſtible materials.

The corn is diſtributed to them every morning; and the ſmalleſt diſhoneſty, when they give it out, is puniſhed by whipping: but it is very ſeldom, indeed, they are expoſed to it. Theſe puniſhments are adjudged by Indian magiſtrates, called *caciques*; there are in every miſſion three of them, choſen by the people from amongſt thoſe whom the miſſionaries have not excluded: but theſe caciques are like the governors of a plantation, paſſive beings, blind executors of the will of their ſuperiors: and their principal functions conſiſt in ſerving as beadles in the church, and their maintaining order and an air of contemplation. The women are never whipped in public, but in an incloſed and ſomewhat diſtant place, leſt perhaps their cries might inſpire too lively a compaſſion, which might ſtimulate the men to revolt; theſe laſt, on the contrary, are expoſed to the view of all their fellow-citizens, that their puniſhment may ſerve as an example. In general they aſk pardon; in which caſe the executioner leſſens the force of his laſhes, but the number of them is never receded from.

The rewards are particular ſmall diſtributions of grain, of which they make little thin cakes, baked on burning coals: and on the great feſtivals the ration is in beef; many of them eat it raw, eſpecially the fat, which they eſteem equal to the beſt butter or cheeſe. They ſkin all animals with the greateſt addreſs; and when they are fat, they make, like the ravens, a croaking of pleaſure, devouring, at the ſame time, the moſt delicate parts with their eyes.

They are frequently permitted to hunt and fiſh on their own account; and on their return they generally make the miſſionaries ſome preſent in game and fiſh; but they always proportion the quantity to what is abſolutely neceſſary for them, always taking care to increaſe it if they hear of any new gueſts who are on a viſit to their ſuperiors. The women rear fowls about their cabins, the eggs of which they give their children. Theſe fowls are the property of the Indians, as well as their clothes, and other little articles of houſehold furniture, and thoſe neceſſary for the chace. There is no inſtance of their having robbed each other, though their faſtenings to the doors conſiſt only of a ſimple bundle of ſtraw, which they place acroſs the entrance when all the inhabitants are abſent.

The men in the miſſions have ſacrificed much more to Chriſtianity than the women; becauſe they were accuſtomed to polygamy, and were even in the cuſtom of eſpouſing all the ſiſters of a family. The women, on the other hand, have acquired the advantage of excluſively receiving the careſſes of one man only. With this, however, it would appear that they are not ſatisfied; for the religious have found it neceſſary to conſtitute themſelves the guardians of female virtue. At an hour after ſupper, they have the care of ſhutting up, under lock and key, all thoſe whoſe huſbands are abſent, as well as the young girls above nine years of age; and during the day they are entruſted to the ſuperintendance of the matrons. So many precautions are ſtill inſufficient; for our voyagers ſaw men in the ſtocks, and women in irons, for having deceived the vigilance of theſe female arguſſes, who had not been ſufficiently ſharp-ſighted.

The converted Indians have preſerved all the ancient uſages which their new religion does not prohibit; the ſame cabins, the ſame games, the ſame dreſſes: that of the richeſt conſiſts of an otter's ſkin cloak, which covers their loins, and deſcends below their groin; the moſt lazy have only a ſimple piece of linen cloth, with which they are furniſhed by the miſſion, for the purpoſe of hiding their nakedneſs; and a ſmall cloak of rabbit's ſkin covers their ſhoulders, which is faſtened with a pack-thread under the chin; the head and the reſt of the body is abſolutely naked; ſome of them, however, have hats of ſtraw, very neatly matted. The womens dreſs is a cloak of deer ſkin, ill tanned; thoſe of the miſſions have a cuſtom of making a ſmall boddice, with ſleeves, of them: it is their only apparel, with a ſmall apron of ruſhes, and a petticoat of ſtag's ſkin, which covers their loins, and deſcends to the middle of the leg. The young girls, under nine years of age, have merely a ſimple girdle; and the children of the other ſex are quite naked.

The independent ſavages are very frequently at war; but the fear of the Spaniards makes them reſpect their miſſions; and this, perhaps, is not one of the leaſt cauſes of the augmentation of the Chriſtian villages. Their arms are the bow, and arrow pointed with a flint very ſkilfully worked: theſe bows are made of wood, and ſtrung with the ſinews of an ox. Our author was aſſured, that they neither eat their priſoners, nor their enemies killed in battle; that, nevertheleſs, when they had

Moors. had vanquiſhed, and put to death on the field of battle, chiefs, or very courageous men, they have eaten ſome pieces of them, leſs as a ſign of hatred or revenge, than as a homage which they paid to their valour, and in the full perſuaſion that this food would be likely to increaſe their own courage. They ſcalp the vanquiſhed as in Canada, and pluck out their eyes; which they have the art of preſerving free from corruption, and which they carefully keep as precious ſigns of their victory. Their cuſtom is to burn their dead, and to depoſit their aſhes in morais.

MOORS, in common language, are the natives of MOROCCO, of whom an account is given under that title in the *Encyclopædia*; but there is another people, a mixed race, called alſo MOORS, who lead a wandering and paſtoral life in the habitable parts of the Great Deſert, and in the countries adjacent to it. Of the origin of theſe Mooriſh tribes, as diſtinguiſhed from the inhabitants of Barbary, nothing farther ſeems to be known than what is related by John Leo the African; whoſe account may be abridged as follows:

Before the Arabian conqueſt, about the middle of the ſeventh century, all the inhabitants of Africa, whether they were deſcended from Numidians, Phœnicians, Carthaginians, Romans, Vandals, or Goths, were comprehended under the general name of *Mauri* or Moors. All theſe nations were converted to the religion of Mahomet, during the Arabian empire under the Kaliphs. About this time many of the Numidian tribes, who led a wandering life in the deſert, and ſupported themſelves upon the produce of their cattle, retired ſouthward acroſs the Great Deſert, to avoid the fury of the Arabians; and by one of thoſe tribes, ſays Leo (that of Zanhaga), were diſcovered, and conquered, the Negro nations on the Niger. By the Niger, is here undoubtedly meant the river of Senegal, which in the Mandingo language is called *Baſing*, or the Black River.

To what extent theſe people are now ſpread over the African continent, it is difficult to aſcertain. There is reaſon to believe, that their dominion ſtretches from weſt to eaſt, in a narrow line or belt, from the mouth of the Senegal (on the northern ſide of that river) to the confines of Abyſſinia. Mr Park deſcribes them as reſembling, in complexion, the Mulattoes of the Weſt Indies, and as having cruelty and low cunning pictured in their countenances. "From the ſtaring wildneſs in their eyes (ſays he), a ſtranger would immediately ſet them down as a nation of lunatics. The treachery and malevolence of their character are manifeſted in their plundering excurſions againſt the Negro villages. Oftentimes, without the ſmalleſt provocation, and ſometimes under the faireſt profeſſions of friendſhip, they will ſuddenly ſeize upon the Negroes cattle, and even on the inhabitants themſelves. The Negroes very ſeldom retaliate. The enterpriſing boldneſs of the Moors, their knowledge of the country, and, above all, the ſuperior fleetneſs of their horſes, make them ſuch formidable enemies, that the petty Negro ſtates, which border upon the deſert, are in continual alarm while the Mooriſh tribes are in the vicinity, and are too much awed to think of reſiſtance.

"Like the roving Arabs, the Moors frequently remove from one place to another, according to the ſeaſon of the year, or the convenience of paſturage. In the month of February, when the heat of the ſun ſcorches up every ſort of vegetation in the deſert, they ſtrike their tents, and approach the Negro country to the ſouth; where they reſide until the rains commence, in the month of July. At this time, having purchaſed corn, and other neceſſaries from the Negroes, in exchange for ſalt, they again depart to the northward, and continue in the deſert until the rains are over, and that part of the country becomes burnt up and barren.

Moor Morinda

"This wandering and reſtleſs way of life, while it inures them to hardſhips, ſtrengthens, at the ſame time, the bonds of their little ſociety, and creates in them an averſion towards ſtrangers, which is almoſt inſurmountable. Cut off from all intercourſe with civilized nations, and boaſting an advantage over the Negroes, by poſſeſſing, though in a very limited degree, the knowledge of letters, they are at once the vaineſt and proudeſt, and perhaps the moſt bigotted, ferocious, and intolerant, of all the nations on the earth; combining in their character the blind ſuperſtition of the Negro, with the ſavage cruelty and treachery of the Arab." But for them Mr Park would have accompliſhed the utmoſt object of his miſſion, and have reached Tombuctoo, and even Houſſa, with no other danger than what ariſes neceſſarily from the climate, from wild beaſts, and from the poor accommodation afforded in the huts of the hoſpitable Negroes. The wandering Moors, however, have all been taught to regard the Chriſtian name with inconceivable abhorrence; and to conſider it nearly as lawful to murder a European as it would be to kill a dog. It is, therefore, much leſs ſurpriſing that our traveller did not proceed farther along the banks of the Niger, than that he eſcaped the ſnares of ſo relentleſs a people.

MORINDA, is a plant, of which a very meagre deſcription has been given in the *Encyclopædia*, though it is of much importance in oriental commerce. It is cultivated to a great extent in the province of *Malwa* in the Eaſt Indies, where it furniſhes a valuable dye ſtuff; and is thus deſcribed by William Hunter, Eſq; in the fourth volume of the Aſiatic Reſearches:

"It is a tree of a middling ſize; the *root* branchy; the *trunk* columnar, erect, covered with a ſcabrous bark. *Branches*, from the upper part of the trunk, ſcattered; of the ſtructure of the trunk. *Leaves* (terminal) oval, obtuſe, entire (mature), oppoſite, decuſſated, ovate, pointed at both ends, ſmooth, with very ſhort petioles. *Stipules*, lanced, very ſmall, withering. *Peduncles*, f the axils of the leaves, ſolitary, bearing an aggregate flower. *Calyx*, common receptacle roundiſh, collecting the ſeſſile flowers into an irregular head. *Perianth*, moſt entire, ſcarce obſervable above. *Corol*, one petalled, funnel-form. *Tube*, cylindric: *Border*, five cleft; the *diviſions* lanced. *Stamen: Filaments*, five, threadform, ariſing from the tube, and adhering to it through two thirds of their length, a little ſhorter than the tube. *Anthers*, linear, erect. *Piſtil. Germ*, beneath, four celled, containing the rudiments of four ſeeds. *Style*, thread form, longer than the ſtamens. *Stigma*, two-cleft, thickiſh. *Pericarp*, common, irregular, divided on the ſurface into irregular angular ſpaces; compoſed of berries, pyramidal, compreſſed on all ſides by the adjacent ones, and concreted with them; lopped; containing towards the baſe a fleſhy pulp. *Seeds*, in each berry four; towards the point oblong, externally convex, internally angular."

The species here described is the *morinda arborea pedunculis solitariis* of Linnæus. It grows best in a black rich soil, free from stones, in situations moderately moist, not too high, yet sufficiently elevated to prevent the rain water from stagnating, and where a supply of water can be had for the dry months. As the colouring matter, for which alone it is valuable, resides chiefly in the bark of the root, the small twigs, which contain little wood, bear a higher price than the larger pieces. The natives employ it in dyeing a pale red, or clay colour; which Mr Hunter says is more valuable for its durability than for its beauty. They likewise use it in dyeing a dark purple or chocolate colour: but for the process, in both cases, we must refer to the original memoir.

MORION, in botany, a name given by the ancients to a kind of nightshade. See SOLANUM, *Encycl.*

MORION, in ancient mineralogy, a name given to one of the semipellucid gems, more commonly called *pramnion*. It is a stone appearing externally of a fine deep black; but when held up against a candle, or against the sun beams, it gives a very beautiful red in different degrees.

MOSHAIRA, or MOSHAHEREH, pension or allowance in Bengal.

MOSS, the name given in Scotland, and we believe also in some parts of England, to what is more properly called a *morass*, a *fen*, or a *bog*. On the formation of these mosses some conjectures have been hazarded in the *Encyclopædia*, where the reader will likewise find a copious account of the method which has for many years been successfully employed to convert the MOSS OF KINCARDINE into an arable soil, or rather to remove the substance called *moss* or *peat* from the rich soil which is found below it. A method, however, has been invented by Mr John Smith of Swindrig-muir, in the shire of Ayr, for *actually* converting the substance called moss into a vegetable mould, which has been found by experience to carry rich crops of corn, hay, potatoes, &c. Of this gentleman's practice we have the following account in a small pamphlet published in Edinburgh, 1798, by Fairbairn and Dickson.

"The first thing to be done is to mark off, and cut out, proper main or master drains, in order to carry off the superfluous water, taking care to preserve the greatest possible level; which drains are so constructed as to divide the field into inclosures from six to ten Scotch acres. If the moss hangs or declines, the inclosures may be of any dimension whatever. The dimensions of these drains when first made are eight feet wide, by four and a half feet deep, declining to two and a half feet at bottom, and cost at the rate of one shilling per fall of eighteen and a half feet, running measure. The ridges are then to be marked off regularly, six or seven yards broad, formed with the spade in the manner following.

"In the centre of each ridge, a space of about 20 inches is allowed to remain untouched, on each side of which a furrow is opened, and turned upon the untouched space, so as completely to cover it (like what is called the feering of a gathered ridge). Thus begun, the work is continued, by cutting with the spade, in width about 12 inches, and turning it over to appearance as if done with a plough, until you come to the division furrow, which should be two feet wide, cut out and thrown upon the sides of the ridges. The depth of the division furrow is to be regulated by circumstances, according as the moss is wet or dry, but so as to answer the purpose of as it were bleeding the moss, and conducting the water to the main drains.

"It may be here observed, that the success of the aftercrops depends very much upon a proper formation of the ridges. They must not be made too high in the middle, for there they will be too dry like a peat, upon which the lime cannot act, and near the furrows they will be too wet, which is equally prejudicial; they should therefore be constructed with a gentle declivity to the furrows, so as the rain which falls may rather filtrate through the ridge to the furrows than run quickly off the surface.

"The next operation is to top-dress the ridges with lime, at the rate of from four to eight chalders per acre. Five Winchester bushels make a boll, and eight bolls a chalder of shell lime, producing sixteen bolls powdered lime. The quicker the lime is put on after being slacked the better.

"The proper season to prepare the moss for a first crop is early the preceding summer; in that case the lime, aided by the heat, the after rains, and the winter frosts, makes considerable progress in the process of putrefaction, consequently forms a mould to receive the seed.

"Though oats have sometimes succeeded as a first crop, potatoes have been found greatly preferable. The method of planting them is simple, and attended with little expence. The moss, prepared by ridges, and limed as before described, beds for the potatoes are, in the spring, marked off, across the ridges, five or six feet broad, with intermediate spaces of about two feet, as furrows or trenches. The beds are covered over with a thin stratum of dung, about eighteeen single-horse carts to an acre, the cuttings of the potatoes are laid or placed upon the beds, about ten or twelve inches asunder, and the whole covered over with a thin stratum of moss from the intermediate trenches, which is followed by another covering from the trenches when the potatoe plants make their first appearance; the covering in whole four or five inches. In this state they remain without any hoeing till the crop is taken up. The produce on Mr Smith's moss has never been less than from forty to fifty bolls of excellent potatoes, eight Winchester bushels to the boll, and the bushel a little heaped.

"When the potatoe crop is removed, the ridges are again formed as before described, and the division-furrow cleared out. In performing this part of the work, it will naturally occur, that a great part of the manured surface will be buried in filling up the trenches between the potatoe beds: but that is not the case; the workman makes two cuts with the spade, at eighteen inches distance, upon the side of the trench; another, one foot from the edge of it, as deep as the trench; which, instead of turning over, he presses a foot forward into the trench, which is continued the length of it; and when he comes to the other side he does the same, making both meet, and so proceeds; so that no part of the manured surface is thrown down, and the ridge is left in the same form as before the lazy-beds* were made.

"When the potatoe crop is taken off, and the ridges formed as before described, they remain in that state till spring, when oats are sown (a wet or dry season has

* This is a vulgar Scottish phrase for beds of a particular kind of potatoe.

Moss. from experience been found a matter of indifference), and harrowed in with a small harrow drawn by two men. Four men with ease harrow at least one acre one rood per day, two and two by turns with the harrow, and the other two in the interim with spades, smoothing the inequalities, breaking and dividing the mould, and clearing out the division furrows; which last in all operations upon moss are essentially necessary. The early or hot seed oats are always preferred for seed. The late or cold seed runs too much to straw, falls down, and becomes floony, consequently the grain is of mean quality, and unproductive in meal.

"The produce of the first crop of oats after potatoes is seldom less than ten bolls per acre, the Linlithgow boll of six Winchester bushels, and considerably more has been known; as good grain in quality, and meals as well as any in the country. It has been sold when growing, what is called upon the foot, including the straw, from eight to ten pounds per acre. To prepare for a second crop of oats, the ridges must be dug across, and turned over in the manner before described, and the division furrows cleared out as soon as convenient after the first crop is removed.

"Such is the effect of lime in consolidating moss, aided by the draining, that often after the second, and always after the third year, it can be ploughed by horses within two bouts or stitches of the division furrow; and also harrowed by horses, and the crops taken off by carts.

"Five and often six consecutive crops of oats are taken, without any other manure than what it received the first year for potatoes, without any apparent signs of it being exhausted. The produce of the first two crops of oats has been mentioned to be ten bolls, and the third, fourth, fifth, and sixth, produce from six to ten bolls per acre. The moss is now turned into a seeming rich dark brown mould; and what renders it less productive of corn crops the fourth, fifth, and sixth years is, its naturally running into sweet and luxuriant grasses. The soft meadow grass, the daisy, some plaintain, but principally the white clover, are the most prevalent grasses; or more probably it may be ascribed to these crops being ploughed, in place of being dug with the spade, as the former years were. Along with the fifth or sixth crop of oats, rye grass is sown, which, with the natural grasses in general, produce an abundant crop of hay.

"If the moss in the original state has been wet and spongy, it will be found to have subsided some feet after the third or fourth year's operation has been performed; but care must always be taken to deepen, clear out, and keep clear the main drains and the division furrows, to prevent a superabundance of moisture, which would infallibly be the case were they neglected in consequence of, the subsidence of the moss. Indeed moss of all sorts will subside less or more, in proportion as it has been dry or wet in its original state; at the same time, as stated before, care must be taken not to lay it too dry, but to keep in a proper degree of temperature between these two extremes."

By having recourse to the pamphlet from which this extract has been made, the reader may satisfy himself of the real advantages of this species of agriculture. The author calculates, with much apparent fairness, the expence of improvement, and the value of each crop, and concludes that no waste can be improved with equal advantage as moss. It must not, however, be concealed, that we have heard practical farmers, who seemed to be acquainted with the subject, give it as their opinion that this mode of cultivation answers only in mosses of no great depth; though our author affirms that it has with great success been practised by Mr Smith in mosses of the depth of 14 feet.

Motion

MOTION IN FLUIDS. When in the publication of this *Supplement* we had arrived at the title FLUIDS, we were struck with the importance given, in some of the journals, to *The Experimental Researches of Venturi concerning the Principle of the lateral communication of Motion in Fluids, applied to the Explanation of various Hydraulic Phenomena*. Of these researches we intended to lay an abridged account before our readers under the present title; but having examined the work with some attention, we find in it hardly any thing of consequence which the mechanical philosopher may not learn from our articles *RESISTANCE of Fluids* and RIVERS in the *Encyclopædia*. That our readers, however, may find something under a title to which we rashly referred them, we shall, in the words of Nicholson's Journal of Natural Philosophy, &c. inform them what Venturi's work contains.

"This author, who is professor of experimental philosophy at Modena, has introduced an horizontal current of water into a vessel filled with the same fluid at rest. This stream entering the vessel with a certain velocity, passes through a portion of the fluid, and is then received in an inclined channel, the bottom of which gradually rises until it passes over the border or rim of the vessel itself. The effect is found to be, not only that the stream itself passes out of the vessel through the channel, but carries along with it the fluid contained in the vessel; so that after a short time no more of the fluid remains than was originally below the aperture at which the stream enters. This fact is adopted as a principle or primitive phenomenon by the author, under the denomination of the lateral communication of motion in fluids, and to this he refers many important hydraulic facts. He does not undertake to give an explanation of this principle, but shews that the mutual attraction of the particles of water is far from being a sufficient cause to account for it.

The first phenomenon which the author proposes to explain by this established principle, is the emission of a fluid through different adjutages applied to the reservoir which contains it. It is known that the vein of fluid which issues from an orifice or perforation through a thin plate, becomes contracted, so as to exhibit a section equal to about 0,64 of the orifice itself, supposed to be circular; and that the place of the greatest contraction is usually at the distance of one semi-diameter of the orifice itself. If a small adjutage be adapted to the orifice, having its internal cavity of the same conoidal form as the fluid itself affects in that interval, the expenditure is the same as by the simple orifice. But if at the extremity of this adjutage a cylindric tube be affixed, of a greater diameter than that of the contracted vein, or a divergent conical tube, the expence of fluid increases, and may exceed the double of that which passes through the aperture in the thin plate, though the adjutage possess an horizontal or even ascending direction.

By

By the interposition of a small adjutage, adapted to the form of the contracted vein, Venturi ascertained, in the first place, that there is an increase of velocity in the tubes he employed, though the velocity of emission itself be less than that of the stream which issues from a hole in a thin plate. He afterwards proves, by the fact, that the interior velocity and expenditure of fluid, which is increased through tubes, even in the horizontal or ascending direction, is owing to the pressure of the atmosphere. If the smallest hole be made in the side of the tube near the place of contraction of the vein, the increased expenditure does not take place; and when a vertical tube is inserted in such a hole, the lower end of which tube is immersed in water or mercury, it is found that aspiration takes place, and the water or mercury rises; and this aspiration in conical tubes is less in proportion, as the place of insertion of the upright tube is more remote from the section where the greatest contraction would have taken place. And, lastly, the difference between the expenditure of fluid, through an orifice made in a thin plate, and that which is observed through an additional tube, does not take place in vacuo.

The influence of the weight of the atmosphere on the horizontal or ascending flux being thus established, the author considers it as a secondary cause, referable to, and explicable by, his principle of the lateral communication of motion in fluids. In conical divergent tubes, for example, the effect of this lateral communication is, that the central cylindrical jet, having for its basis the section of the contracted vein, carries with it the lateral fluid which would have remained stagnant in the enlarged part of the cone. Hence a vacuum tends to be produced in this enlarged part which surrounds the central cylindric stream; the pressure of the atmosphere becomes active to supply the void, and is exerted on the surface of the reservoir, so as to increase the velocity of the fluid at the interior extremity of the tube.

The author proves, that the velocity or total expenditure of fluid through an aperture of given dimensions, may be increased by a proper adjutage in the proportion of 24 to 10: he applies this result to the construction of the funnels of chimneys. He determines the loss of emitted fluid, which may be sustained by sinuosity in pipes. He shews by experiment, that a pipe which is enlarged in any part affords a much less quantity of fluid than if it were throughout of a diameter equal to that of its smallest section. This, as he remarks, is a circumstance to which sufficient attention has not been paid in the construction of hydraulic machines. It is not enough to avoid elbows and contractions; for it sometimes happens that, by an intermediate enlargement, the whole of the advantage arising from other judicious dispositions of the parts of the machine is lost.

There are two causes of the increase of expenditure through descending pipes. The first is owing to the lateral communication of motion which takes place in descending pipes, in the same manner as in those which possess an horizontal situation; the second arises from the acceleration by gravity which takes place in the fluid while it falls through the descending tube. This second kind of augmentation was known to the ancients, though they possessed no good theory nor decisive experiments respecting it. The author endeavours to establish a theory on the principle of virtual ascension combined with the pressure of the atmosphere. His deductions are confirmed by experiment, in which he has succeeded so far as to separate the two causes of augmentation, and assigned to each their respective degree of influence.

Professor Venturi then proceeds to different objects of enquiry, to which his principle seemed applicable. He gives the theory of the water blowing machine (see *Water Blowing Machine* in this *Suppl.*), and he determines by calculation the quantity of air which one of these machines can afford in a given time. He observes, that the natural falls of water in the mountains always produce a local wind; and he even thinks, that the falling streams in the internal parts of mountains are in some instances the cause of the winds which issue from caves. He proves, by the facts, that it is possible, in certain instances, to carry off, without any machinery, the waters from a spot of ground, though it may be situated on a lower level than that of the channel which is to receive the water.

The whirlpools, or circular eddies of water so frequent in rivers, are, according to the theory of our author, the effect of motion communicated from the parts of the current which are most rapid, to those lateral parts which are least so. In the application of this principle, he points out the circumstances adapted to produce such eddies at the surface or at the bottom of rivers. He concludes, that every movement of this kind destroys a part of the force of the current, and that in a channel through which water constantly flows, the height of this fluid will be greater than it would have been if the dimensions of the channel had been uniformly reduced to the measure of its smallest section.

There is another kind of whirling motion somewhat different in its nature from these last. It is produced in the water of a reservoir, when it is suffered to flow through an horizontal orifice. The author deduces the theory of these vortices from the doctrine of central forces. The form of the hollow funnel, which in this case opens through the fluid of the reservoir, is a curve of the 64th species of the lines of the third order, enumerated by Newton. Theory and experiment both unite here in proving, that it is not only possible, but that there really exists in nature a vortex, the concavity of which is convex towards the axis, and of which the revolutions of its different parts follow the ratio of the square of the distance from the centre. Daniel Bernoulli was in the wrong, in his Hydrodynamics, to reproach Newton for having supposed a vortex to be moved according to this law.

In the last place, the author considers that lateral communication of motion which takes place in the air as well as in the water. This is the cause of such local and partial winds as sometimes blow contrary to the direction of the general wind. It is by virtue of the same principle, that the resonant vibration, excited laterally in the extremity of an organ pipe, is communicated to the whole column of air contained in the pipe itself.

From the same principle, the author deduces the augmentation of force which sound receives in conical divergent tubes, compared with those of a cylindrical form. On this occasion, he points out the remarkable diffe-

differences which appear to take place between the resonant vibrations of air contained in a tube, and the sonorous pulsations propagated through the open atmosphere. See *Speaking Trumpet*, Encycl.

In an appendix, Venturi relates different experiments which he has made to determine the convergence and velocity of the fluid filaments which press forward to issue out of a reservoir by an orifice through a thin plate. He proves, by a very clear experiment, that the contraction of the vein is made at a greater distance from the orifice under strong than under weak pressures. He explains why, in a right lined orifice, the sides of the contracted vein correspond with the angles of the orifice and the angles with the sides. He examines the expenditure through a tube, the extremity of which is thrust into the reservoir itself, according to the method of Borda in the Memoirs of the Academy of Sciences for the year 1766."

For a full account of the author's experiments, and his deductions from them, we refer the reader either to the original work, intitled, *Recherches expérimentales sur le Principe de la Communication latérale du Mouvement dans les Fluides, appliqué à l'Explication de différens Phénomènes hydrauliques. Par le Citoyen J. B. Venturi, Professeur de Physique expérimentale à Modène, Membre de la Societé Italienne, &c. &c. A Paris chez Houel et Ducros, Rue du Bacq,* N° 940—*Théophile Barrois, Rue Haute-feuille,* N° 22. *Ann.* VI. 1797—or to the 2d and 3d vols of the valuable Journal from which this abstract is taken

MOURZOUK, the capital of Fezzan in Africa, is situated on a small river, and supplied with water from a multitude of springs and wells. Being formerly built of stone, it still retains the appellation of a Christian town; and the medley which it presents to the eye, of the vast ruins of ancient buildings, and the humble cottages of earth and sand that form the dwellings of its present Arab inhabitants, is singularly grotesque and strange. It is surrounded by a high wall, which not only affords the means of defence, but enables the government to collect, at its three gates, a tax on all goods (provisions excepted) that are brought for the supply of its people. A caravan sets out annually from Mesurata to this place; and hence the Fezzaners themselves dispatch every year a caravan to Cashna and another to Bornou. For the latitude of Mourzouk, see Fezzan in this *Suppl.* Dr Brookes, in his Gazetteer, places it in 15° 5' E. Long.

MOWAZZEF, in Bengal, fixed revenue.

MOZART, the celebrated German musician, was born at Salzburg in the year 1756. His father was also a musician of some eminence, but not to be compared with the son; of whom we have the following account in one of the monthly miscellanies, taken by Mr Bushby from some biographical sketches by two eminent German professors.

At the age of three years, young Mozart, attending to the lessons which his sister, then seven years old, was receiving at the harpsichord, he became captivated with harmony; and when she had left the instrument, he would instantly place himself at it, find the thirds, sound them with the liveliest joy, and employ whole hours at the exercise. His father, urged by such early and striking indications of genius, immediately began to teach him some little airs; and soon perceived that his pupil improved even beyond the hopes he had formed of him. Half an hour was generally sufficient for his acquiring a minuet or a little song, which, when once learned, he would of himself perform with taste and expression.

At the age of six years he had made such a progress as to be able to compose short pieces for the harpsichord, which his father was obliged to commit to paper for him. From that time nothing made any impression upon him but harmony; and infantine amusements lost all their attractions unless music had a share in them. He advanced from day to day, not by ordinary and insensible degrees, but with a rapidity which hourly excited new surprise in his parents—the happy witnesses of his progress.

His father returning home one day with a stranger, found little Mozart with a pen in his hand. "What are you writing," said he? "A concerto for the harpsichord," replied the child. "Let us see it (rejoined the father); it is a marvellous concerto without doubt." He then took the paper, and saw nothing at first but a mass of notes mingled with blots of ink by the mal address of the young composer, who, unskilled in the management of the pen, had dipped it too freely in the ink; and having blotted and smeared his paper, had endeavoured to make out his ideas with his fingers; but on a closer examination, his father was lost in wonder; and his eyes delighted and flowing with tears, became rivetted to the notes. "See (exclaimed he to the stranger) how just and regular it all is! but it is impossible to play it; it is too difficult." "It is a concerto (said the child), and must be practised till one can play it. Hear how this part goes." He then sat down to perform it; but was not able to execute the passages with sufficient fluency to do justice to his own ideas. Extraordinary as his manual facility was universally allowed to be for his age, it did not keep pace with the progress of his knowledge and invention. Such an instance of intellectual advancement, in a child only six years of age, is so far out of the common road of nature, that we can only contemplate the fact with astonishment, and acknowledge, that the possible rapidity of mental maturation is not to be calculated.

In the year 1762, his father took him and his sister to Munich, where he performed a concerto before the elector, which excited the admiration of the whole court; nor was he less applauded at Vienna, where the emperor called him the *little sorcerer*.

His father gave him lessons only on the harpsichord; but he privately taught himself the violin; and his command of the instrument afforded the elder Mozart the utmost surprise, when he one day at a concert took a second violin, and acquitted himself with more than passable address. True genius sees no obstacles. It will not therefore excite our wonder, if his constant success in whatever he attempted begot an unbounded confidence in his own powers; he had even the *laudable* hardihood to undertake to qualify himself for the *first* violin, and did not long remain short of the necessary proficiency.

He had an ear so correct, that he felt the most minute discordancy; and such a fondness for study, that it was frequently necessary to take him by force from the instrument. This love of application never diminished. He every day passed a considerable time at his harpsichord, and generally practised till a late hour at night.

Mozart. night. Another characteriſtical trait of real genius; always full of its object, and loſt as it were in itſelf.

In the year 1763 he made, with his father and ſiſter, his firſt grand muſical journey. He viſited Paris; and was heard by the French court in the chapel-royal at Verſailles, where his talent on the organ was admired even more than on the harpſichord. At Paris the muſical travellers gave two concerts, which procured them the higheſt reputation, and the diſtinction of public portraits. It was here that a ſet of ſonatas for the harpſichord, ſome of his earlieſt compoſitions, were engraved and publiſhed.

From Paris they went to London, where they alſo gave two concerts, conſiſting of ſymphonies compoſed by young Mozart, who even at that early age ſang alſo with much expreſſion, and practiſed publicly with his ſiſter. Mozart played already at ſight, and in a concert, at which the king was one of his auditors, a baſs being placed before him as a *ground*, immediately applied to it a moſt beautiful melody. Thoſe who are beſt acquainted with the extent of ſuch a taſk, will be the moſt aſtoniſhed at ſuch mature familiarity with the intricacies of the ſcience, and ſuch prompt and ready invention in ſo juvenile a mind.

From London, where Mozart alſo publiſhed ſix ſonatas for the harpſichord, the muſical family went to Holland, thence again to France, and in 1766 returned to Salzburg. There this extraordinary youth remained more than a year in perfect repoſe; devoting the whole of his time to the ſtudy of compoſition, the principles of which he ſcrutinized with the depth and penetration of confirmed manhood. Emmanuel Bach, Haſſe, and Handel, were his chief guides and models; though he by no means neglected the old Italian maſters.

In 1768 he again viſited Vienna, where Joſeph II. engaged him to ſet to muſic a comic opera, entitled, *La Finta Semplice*, which obtained the approbation of Haſſe and Metataſio. At the houſe of the prince of Kaunitz, it often happened that the firſt Italian air which came to hand would be given him, that in the preſence of the company he might add to it accompaniments for numerous inſtruments; which he would write in the firſt ſtyle of excellence, and without the leaſt premeditation. This is at once a proof with what acuteneſs of obſervation he had liſtened to the muſic of the beſt maſters; how intimate he had already rendered himſelf with the characters, capacities, and effects of the different inſtruments; and what ſkill he had acquired in that abſtruſe art of mixed combination which, while it calculates the conjoint effect of ſounds, as they regard the eſtabliſhed laws of harmony, accommodates the different parts to the ſcales, tones, and powers of the reſpective inſtruments by which they are to be executed. It was at this time alſo that, although but twelve years of age, he compoſed the muſic for the conſecration of the church of orphans, at the performance of which he himſelf preſided.

In 1769 Mozart again returned to Salzburg, where he became *maitre de concert*. Not having yet ſeen Italy, in December of the ſame year he ſet out for that ſeat of the fine arts. Thoſe talents which had already excited the admiration of Germany, France, and England, now awakened in that land of muſical taſte the moſt lively enthuſiaſm.

In 1771 he had no ſooner given perſonal proofs of his genius, than *la ſcrittura* for the following carnival was conferred upon him. He viſited Bologna, then as famous for harmonic excellence as Naples, where the celebrated theoriſt Martini was amazed to ſee a German boy work and execute the theme of a fugue which he preſented to him, in the extraordinary ſtyle in which Mozart acquitted himſelf. He next went to Florence. Florence even enhanced the eulogiums which Bologna had laviſhed upon him.

During the holy week he arrived at Rome, and aſſiſted at the *Miſerere* in the Sixtine chapel: which performance is juſtly conſidered as the *ne plus ultra* of vocal muſic. This circumſtance claims particular notice, as inducing a proof of another faculty of his mind, only to be equalled by thoſe wonderful powers which he had already demonſtrated. He was prohibited from taking a copy of this *Miſerere*, and therefore piqued himſelf on retaining it in his memory. Having heard it with attention, he went home, made out a manuſcript from recollection, returned the next day to the chapel, heard the piece a ſecond time, corrected the rough draught, and produced a tranſcript which ſurpriſed all Rome. This *Miſerere* formed a *ſcorer* numerous in its parts, and extremely difficult of execution. His mind had embraced and retained the whole!

He ſoon after received from the Pope the order of the gilt ſpur; and at Bologna was complimented, by an unanimous deciſion, with the title of *Member and Maſter of the Phil-harmonic Academy*. As a proof, *pro forma*, of his qualifications for this academical honour, a fugue, for four voices, in the church ſtyle, was required of him, and he was ſhut up alone in his chamber. He completed it in half an hour, and received his diploma. This evinced that he poſſeſſed an imagination conſtantly at his command, and that his mind was ſtored with all the riches of his beloved ſcience.

The opera which he compoſed for Milan was called *Mithridates*. This piece procured him *la ſcrittura* for the grand opera of the carnival of 1773, which was his *Lucio Sulla*. At length, after a tour of fifteen months, he returned to Salzburg.

In 1771 Mozart viſited Paris; but not reliſhing the muſic of that capital, he ſoon quitted it, and returned to his domeſtic comforts. In 1781, at the requeſt of the elector of Bavaria, he compoſed the opera of *Idomeneo* for the carnival of that year. The general merit of this opera is ſo great, that it might ſerve alone for the baſis of a diſtinguiſhed reputation. At his twenty-fifth year he was invited to Vienna, where he continued ſpreading, as from a centre, the taſte of his compoſitions through all Germany, and the luſtre of his name over the whole of Europe.

Of all the virtuoſi of the piano forte who then crowded Vienna, Mozart was much the moſt ſkilful. His finger was extraordinarily rapid and taſteful, and the execution of his left hand exceeded every thing that had before been heard. His touch was replete with delicacy and expreſſion; and the profound ſtudy he had beſtowed on his art, gave his performance a ſtyle the moſt brilliant and finiſhed. His compoſitions had a rapid circulation; and in every new piece the connoiſſeurs were ſtruck with the originality of its caſt, the novelty of the paſſages, and the energy of the effect.

Joſeph II. ſolicitous for the perfection of the German opera, engaged Mozart to compoſe a piece. He accordingly

Mozart. cordingly produced *L'enlevement du Serail;* performed for the first time in 1782. It excited the jealousy of the Italian company, who therefore ventured to cabal against it. The emperor, addressing himself to the composer, said, "It is *too fine* for our ears, my dear Mozart, and most *charmingly crowded* with notes." "Precisely what it ought to be," replied the spirited musician, who justly suspected that this remark had been suggested to Joseph by the envious Italians. "Though I cannot describe, as an auricular evidence, (says the faithful author of the biography), the applauses and the admiration which this opera produced at Vienna, yet I have witnessed the enthusiasm it excited at Prague among all the connoisseurs, as well as among those whose ears were less cultivated. It was said, that all which had been heard before was not music: it drew the most overflowing audiences: every body was amazed at its new traits of harmony, and at passages so original, and till then so unheard from wind instruments."

The cautious reader will perhaps hesitate to admit, in its fullest extent, this account by the author of the biography; but even after an allowance for some exaggeration, the most phlegmatic will grant that much must have been atchieved by this great master, to afford a basis for so glowing a picture of the merit and success of *L'enlevement du Serail.* During the composition of this opera, he married Mademoiselle Weber, a distinguished virtuosa; and the piece was supposed to owe to this felicitous circumstance much of that endearing character, that tone of tenderness, and that expression of the softer passions, which form its principal attractions.

"The Marriage of Figaro," which was in the highest repute at all the theatres, was in the year 1787 transformed into an Italian opera; and Mozart, at the instance of the emperor, set it to music. This piece was highly received everywhere, and kept possession of the theatre at Prague during almost the whole of the winter in which it first appeared: numerous extracts were made from it, and the songs and dances of Figaro were vociferated in the streets, the gardens, and the taverns. Mozart came that very winter to Prague, and performed in public on the piano forte. His auditors at all times listened to him with admiration; but whenever he played extempore, and indulged the spontaneous and uninterrupted sallies of his fancy, which he sometimes would for more than half an hour, every one was seized with the most enthusiastic raptures, and acknowledged the unrivalled resources of his imagination. About this time the manager of the theatre contracted with him for the composition of a new opera, which, when produced, was called *Il dissoluto Punito*, or *Don Giovanni.* His reputation was now so exalted, that the Bohemians piqued themselves on the circumstance that this opera was composed for their entertainment.

But this fame, this great and universal applause, had not yet produced to the admired artist any solid advantages; he had obtained no place, no settled income; but subsisted by his operas, and the instructions and occasional concerts which he gave. The profits of these proved insufficient for the style which he was obliged to support; and his finances became much deranged. The critical situation in which he now found himself, made him resolve to quit Vienna, and seek an asylum in London; to which metropolis he had often been invited; but Joseph nominating him *compositeur de la chambre*, though, with a very inadequate salary, he was induced to accept it; and Germany had the advantage of retaining him.

It is lamentable that premature genius too rarely enjoys a long career: The acceleration of nature in the mental powers seems to hurry the progress of the animal œconomy, and to anticipate the regular close of temporal existence.

In the year 1791, Mozart, just after he had received the appointment of *Maitre de chapelle* of the church of St Peter, and when he was only thirty-five years of age, paid the last tribute; and left the world at once to admire the brilliancy, and lament the shortness of his earthly sojournment.

Indefatigable, even to his death, he produced, during the last few months of his life, his three great master pieces *La Flutte Enchantée*, *La Clemence de Titus*, and a *Requiem*, his last production. *La Flutte Enchantée* was composed for one of the theatres at Vienna; and no dramatic *Olio* could ever boast a greater success. Every air struck the audience with a new and sweet surprise; and the *tout ensemble* was calculated to afford the deepest and most varied impressions. This piece had, in fact, so great a number of successive representations, that for a long time it was unnecessary to consult the opera-bill; which only announced a permanent novelty. And the airs selected from it, and repeated throughout the empire, as well in the cottage as in the palace, and which the echoes have resounded in the most distant provinces, favoured the idea that Mozart had actually the design to enchant all Germany with his *Flutte Enchantée.*

La Clemence de Titus was requested by the states of Bohemia for the coronation of Leopold. The composer began it in his carriage during his route to Prague, and finished it in eighteen days.

Some circumstances attending the composition of the piece which we have already mentioned as the last effort of his genius, are too interesting to be omitted. A short time before his death, a stranger came to him with the request that he would compose, as speedily as possible, a *requiem* for a catholic prince, who, perceiving himself on the verge of the grave, wished, by the execution of such a piece, to soothe his mind, and familiarise it to the idea of his approaching dissolution. Mozart undertook the work; and the stranger deposited with him as a security 400 ducats, though the sum demanded was only 200. The composer immediately began the work, and during its progress felt his mind unusually raised and agitated. He became at length so infatuated with his *requiem*, that he employed not only the day, but some hours of the night in its composition. One day, while he was conversing with Madame Mozart on the subject, he declared to her that he could not but be persuaded that it was for himself he was writing this piece. His wife, distressed at her inability to dissipate so melancholy an impression, prevailed on him to give her the *score.* He afterwards appearing somewhat tranquillized, and more master of himself, she returned the *score* to him, and he soon relapsed into his former despondency. On the day of his death he asked for the *requiem*, which was accordingly brought to his bed: "Was I not right (said he), when I declared that it

Mozart. was for myself I was composing this funeral piece?" And the tears trickled from his eyes. This production of a man, impressed during its composition with a presentiment of his approaching death, is *unique* in its kind, and contains passages which have frequently drawn tears from the performers.

Only one complaint escaped him during his malady: "I must quit life (said he), precisely at the moment when I could enjoy it, free from care and inquietude; at the very time when, independent of sordid speculations, and at liberty to follow my own principles and inclinations, I should only have to write from the impulses of my own heart: and I am torn from my family just when in a situation to serve it." Mozart, at the time of his death, was considerably involved in debt; but Vienna and Prague disputed the honour of providing for his widow and children.

The countenance of this great master did not indicate any thing uncommon. He was small of stature; and, except his eyes, which were full of fire, there was nothing to announce superiority of talent. His air, unless when he was at the harpsichord, was that of an absent man. But when he was performing, his whole physiognomy became changed: a profound seriousness recalled and fixed his eyes; and his sentiments were expressed in every movement of his muscles. Never has a musician more successfully embraced the whole extent of his art, and shone with greater lustre in all its departments. His great operas, no less than his most simple songs; his learned symphonies as well as his airy dances—all carry the stamp of the richest imagination, the deepest sensibility, and the purest taste. All his works develope the originality of his genius; and imply a mind great and exalted; an imagination which strikes out for itself a new course. He therefore merits to be ranked with that small number of original geniuses, those *phenomena splendida*, who form an epoch in their art, by carrying it to perfection, or giving it an unknown career.

It is in the employment of wind instruments that Mozart displays his greatest powers. His melody is always simple, natural, and full of force; and expresses with precision the sentiments and individual situations of his personages. He wrote with extraordinary facility. "*La Clemence de Titus*," the reader will recollect, cost him the study of but eighteen days; and his *requiem*, which is equal in length to an opera, was produced in four weeks. It is also worthy of remark, that the overture to his *Don Giovanni* was not begun till the night before the piece was to be performed. At midnight, after having devoted the evening to amusement, he locked himself up in his study, and composed it in a few hours. His memory was wonderfully retentive, as we may judge from his copying by recollection the *miserere* at Rome. But a fact equally astonishing is, that, soon discovering the eagerness of people to procure his works, and fearful that they might be pirated, it was his constant custom to transcribe from the *scores* of his sonatas only a part for one hand, and at the public performance to supply the other by memory.

He very early began to display that true dignity of an artist which renders him indifferent to the praises of those who are unqualified to judge. The commendations of the ignorant great he never considered as fame. His hearers, whether the wealthy or the titled, must have acquired some credit for their judgment before he could be ambitious of their applause. Indeed he entertained so just a sense of scientific elevation and importance, that he would insist upon respect. And the least noise or idle babble, while he was at the instrument, excited a displeasure which he was too indignant to conceal. Once, to the honour of his feelings, he suddenly rose from his seat, and left his inattentive auditory to experience the keen though silent reproach of insulted genius.

His mind was by no means unlettered; nor was it embellished with one science alone. He was master of several languages, and had made considerable progress in the mathematics. He was honest, mild, generous, full of frankness; and with his friends had an air at once amiable, gay, and free from the least tincture of pedantry.

Far from viewing with envy the success of others, a weakness too closely interwoven in the general nature of man, he was always just to the talents of his fellow professors; and valued and respected merit wherever he found it; a clearer proof of which cannot be adduced than the following circumstance: At a concert, where a new piece composed by the celebrated Joseph Haydn was performed, a certain musician, who never discovered any thing worthy of praise except in his own productions, did not fail to criticise the music; exclaiming to Mozart, "There now! there again! why, that is not what *I* should have done:" "No; neither should I (replied Mozart); but do you know why? Because neither you nor I should have been able to conceive it."

Mumbo. MUMBO-JUMBO, a strange bugbear employed by the Pagan Mandingoes (see MANDING, *Suppl.*) for the purpose of keeping their women in subjection. Polygamy being allowed among these people, every man marries as many wives as he can conveniently maintain; and the consequence is, that family quarrels sometimes rise to such a height, that the husband's authority is not sufficient to restore peace among the ladies. On these occasions, the interposition of *Mumbo-Jumbo* is called in; and it is always decisive. This strange minister of justice, who is either the husband himself, or some person instructed by him, disguised in a sort of masquerade habit, made of the bark of trees, and armed with the rod of public authority, announces his coming by loud and dismal screams in the woods near the town. He begins the pantomime at the approach of night; and as soon as it is dark, he enters the town, and proceeds to the *Bentang* or market-place, at which all the inhabitants immediately assemble.

It may easily be supposed that this exhibition is not much relished by the women; for as the person in disguise is entirely unknown to them, every married female suspects that the visit may possibly be intended for herself; but they dare not refuse to appear when they are summoned; and the ceremony commences with songs and dances, which continue till midnight, about which time Mumbo fixes on the offender. This unfortunate victim being thereupon immediately seized, is stripped naked, tied to a post, and severely scourged with Mumbo's rod, amidst the shouts and derision of the whole assembly; and it is remarkable, that the rest of the women are the loudest in their exclamations on this occasion against their unhappy sister. Daylight puts an end to this indecent

indecent and unmanly revel. It is truly astonishing that the women should be deluded by so clumsy an imposture, and that the men should so faithfully keep their own secret. That the women are deluded seems evident; for Mr Park assures us, that the dress of Mumbo is suffered to hang on a tree at the entrance of each town; which could hardly be the case, if the women were not persuaded that it is the dress of some supernatural being.

MUNSHY, a Persian secretary or writer.

MUNSUB, in the language of Bengal, a dignity or command conferred by the emperor.

MUNSUBDAR, a dignitary or commander.

MURRAY (William), afterwards Earl of Mansfield and Lord Chief Justice of England, was the fourth son of David Viscount Stormont. He was born on the 2d day of March 1705 at Perth, in the kingdom of Scotland, of which kingdom his father was a peer. His residence in Scotland, however, was of short duration; for he was carried up to London at the early age of three years. Hence his total exemption from the peculiarities of the dialect of his native country.

At the age of fourteen he was admitted as a king's scholar of Westminster school; and during his residence in that seminary, says his contemporary Bishop Newton, he gave early proofs of his uncommon abilities, not so much in his poetry, as in his other exercises; and particularly in his declamations, which were sure tokens and prognostics of that eloquence which grew up to such maturity and perfection at the bar, and in both houses of parliament. At the election in May 1723, he stood first on the list of those gentlemen who were sent to Oxford, and was entered of Christ Church, June the 18th, in that year. In the year 1727 he had taken the degree of B. A. and on the death of King George the First, was amongst those of the university who composed verses on that event.

In April 1724 he was admitted a student of Lincoln's Inn, though he still continued to reside much in the university; where, on the 26th of June 1730, he took the degree of M. A. and soon afterwards left Oxford, determined to make the tour of Europe before he should devote himself seriously to business. About this period he wrote two letters to a young nobleman on the study of ancient and modern history, which are published by his biographer Mr Holliday, and shew how amply his own mind was then stored with general literature.

On his return to England he commenced his legal studies; but proceeded not in the way then usually adopted, of labouring in the chambers of a special pleader, or copying (to use the words of Blackstone) the trash of an attorney's office. Being blessed with the powers of oratory in their highest perfection, and having soon an opportunity of displaying them, he very early acquired the notice of the chancellor and the judges, as well as the confidence of the inferior practisers. How much he was regarded in the house of lords, Pope's well-known couplet will prove:

> Grac'd as thou art with all the power of words,
> So known, so honour'd at the house of lords.

The graces of his elocution, however, produced their usual effect with a certain class of people, who would not believe that such bright talents could associate with the more solid attainments of the law, or that a man of genius and vivacity could be a profound lawyer. As Pope observed at that time,

> The Temple late two brother serjeants saw,
> Who deem'd each other oracles of law;
> With equal talents these congenial souls,
> One lull'd the exchequer, and one stunn'd the rolls;
> Each had a gravity would make you split,
> And shook his head at Murray as a wit.

It is remarkable that this ridiculous prejudice accompanied Lord Mansfield to the end of his judicial life, in spite of daily proofs exhibited in the court of King's Bench and in the House of Lords, of very profound knowledge of the abstrusest points of jurisprudence. Lord Chesterfield has given his sanction to this unfounded opinion. In a letter to his son, dated Feb. 12. 1754, he says, "The present Solicitor General Murray has less law than many lawyers, but he has more practice than any, merely upon account of his eloquence, of which he has a never-failing stream."

In the outset of Lord Mansfield's life, it will be the less surprising, that a notion should have been entertained of his addicting himself to the pursuits of Belles Lettres too much, when the regard shewn to him by Mr Pope, who despotically ruled the regions of literature at that period, is considered. That great Poet seemed to entertain a particular affection for our young lawyer, and was eager to shew him marks of his regard. He addressed to him his imitation of the 6th Epistle of the First Book of Horace; and even condescended to become his master in the art of elocution. "Mr Murray (says his biographer) was one day surprised by a gentleman of Lincoln's Inn, who could take the liberty of entering his rooms without the ceremonious introduction of a servant, in the singular act of practising the graces of a speaker at a glass, while Pope sat by in the character of a friendly preceptor. Mr Murray, on this occasion, paid that poet the handsome compliment of, *Tu es mihi Mæcenas* (A)."

Whatever propensities this sprightly lawyer might have towards polite literature, he did not permit them to divert his attention from his profession. He soon distinguished himself in an extraordinary manner, as may be seen by those who are conversant with, or choose to refer to the Books of Reports. In the year 1736, the murder of Captain Porteous by a mob in Edinburgh, after he had been reprieved, occasioned a censure to fall on that city, and a bill of pains and penalties was brought into Parliament against the Lord Provost and the corporation; which, after various modifications, and a firm and unabated opposition in every stage of its progress, passed into a law. In both Houses Mr Murray was employed as an advocate, and so much to the satisfaction of his clients, that afterwards, in September 1743, he was presented with the freedom of Edinburgh in a gold box, professedly, as it was rela-

(A) It is thus that eminence is attained even by genius, and Mr Murray was properly employed, though we do not clearly perceive the use of the glass, when his master was watching all his gestures.

red, for his signal services by his speeches to both Houses of Parliament in the conduct of that business.

On the 24th of November 1738, he had married Lady Elizabeth Finch, daughter of the Earl of Winchelsea, and in the month of November 1742, was appointed Solicitor General in the place of Sir John Strange, who resigned (B). He likewise was chosen to represent the town of Boroughbridge in Parliament, for which place he was also returned in 1747 and 1754.

In the month of March 1746-7 he was appointed one of the managers for the impeachment of Lord Lovat by the House of Commons, and it fell to his lot to observe on the evidence previous to the Lords giving their judgment. This task he executed with so much candour, moderation, and gentleman-like propriety, that Lord Talbot, at the conclusion of his speech, paid him the following compliment: "The abilities of the learned manager who just now spoke, never appeared with greater splendour than at this very hour, when his candour and humanity has been joined to those great abilities which have already made him so conspicuous, that I hope one day to see him add lustre to the dignity of the first civil employment in this nation." Lord Lovat himself also bore testimony to the abilities of his adversary: "I thought myself (says his lordship) very much loaded by one Murray (C), who your Lordships know was the bitterest evidence there was against me. I have since suffered by another Mr Murray, who, I must say with pleasure, is an honour to his country, and whose eloquence and learning is much beyond what is to be exprest by an ignorant man like me. I heard him with pleasure, though it was against me. I have the honour to be his relation, though perhaps he neither knows it nor values it. I wish that his being born in the North may not hinder him from the preferment that his merit and learning deserve."

During the time that Mr Murray continued in office, he supported, with great ability, the administration with which he was connected; and, of course, rendered himself obnoxious to those who were in opposition. Nothing, however, could be urged either against his public conduct or his private life; but he was involved in some trouble by an ill-devised tale, concurring with the known principles of the family of Stormont, to make him suspected of Jacobitism. Of this affair, a full and particular account is given by the late Lord Melcombe in the following words:

"Messrs Murray, Fawcett, and Stone, were much acquainted, if not school-fellows, in earlier life. Their fortune led them different ways; Fawcett's was to be a country lawyer and recorder of Newcastle. Johnson, now Bishop of Gloucester, was one of their associates. On the day the King's birth-day was kept, they dined at the Dean of Durham's at Durham; this Fawcett, Lord Ravensworth, Major Davison, and one or two more, who retired after dinner into another room. The conversation turning upon the late Bishop of Gloucester's preferments, it was asked who was to have his prebend of Durham? The Dean said, that the last news from London was, that Dr Johnson was to have it: Fawcett said, he was glad that Johnson got off so well, for he remembered him a Jacobite several years ago, and that he used to be with a relation of his who was very disaffected, one Vermon, a mercer, where the Pretender's health was frequently drunk. This passing among a few familiar acquaintance, was thought no more of at the time: it spread, however, so much in the North (how I never heard accounted for), and reached town in such a manner, that Mr Pelham thought it necessary to desire Mr Vane, who was a friend to Fawcett, and who employed him in his business, to write to Fawcett, to know if he had said this of Johnson, and if he had, if it was true.

"This letter was written on the 9th of January; it came to Newcastle the Friday following. Fawcett was much surprised; but the post going out in a few hours after its arrival, he immediately acknowledged the letter by a long, but not very explicit, answer. This Friday happened to be the club day of the neighbouring gentlemen at Newcastle. As soon as Lord Ravensworth, who was a patron and employer of Fawcett, came into the town, Fawcett acquainted him with the extraordinary letter he had received; he told him that he had already answered it; and being asked to shew the copy, said he kept none; but desired Lord Ravensworth to recollect if he held such a conversation at the Deanry of Durham the day appointed for the birth-day. Ravensworth recollected nothing at all of it: they went to the club together, and Ravensworth went the next morning to see his mother in the neighbourhood, with whom he staid till Monday; but this thing of such consequence lying upon his thoughts, he returned by Newcastle. He and Fawcett had another conversation; and in endeavouring to refresh each other's memory about this dreadful delinquency of Johnson, Fawcett said he could not recollect positively at such a distance of time, whether Johnson drank these healths, or had been present at the drinking of them, but that Murray and Stone had done both several times. Ravensworth was excessively alarmed at this with relation to Stone, on account of his office about the prince; and thus the affair of Johnson was quite forgotten, and the episode became the principal part. There were many more conferences between Ravensworth and Fawcett

Murray.

(B) On this occasion a doggrel poem was published by one Morgan, a person then at the bar, entitled, "The Causidicade," in which all the principal lawyers were supposed to urge their respective claims to the post. At the conclusion it is said,

> Then Murray, prepar'd with a fine panegyric
> In praise of himself, would have spoke it like Garrick;
> But the President stopping him said, "As in truth
> Your worth and your praise is in every one's mouth,
> 'Tis needless to urge what's notoriously known,
> The office, by merit, is your's all must own;
> The voice of the public approves of the thing,
> Concurring with that of the Court and the King."

(C) One of the evidences against him.

Murray. ect upon this subject, in which the latter always persisted that Stone and Murray were present at the drinking, and did drink those healths. It may be observed here, that when he was examined upon oath, he swore to the year 1731 or 1732, at latest. Fawcett comes up as usual about his law business, and is examined by Messrs Pelham and Vane, who never had heard of Murray or Stone being named: he is asked, and answers only with relation to Johnson, never mentioning either of the others; but the love of his country, his king, and posterity, burned so strongly in Ravensworth's bosom, that he could have no rest till he had discovered this enormity. Accordingly, when he came to town, he acquainted the ministry and almost all his great friends with it, and insisted upon the removal of Stone. The ministry would have slighted it as it deserved; but as he persisted, and had told so many of it, they could not help laying it before the king, who, though he himself slighted it, was advised to examine it; which examination produced this most injudicious proceeding in parliament *."

* Lord Melcombe's Diary, p. 210.

This is Lord Melcombe's account; and the same author informs us, that Mr Murray, when he heard of the committee being appointed to examine this idle affair, sent a message to the king, humbly to acquaint him, that if he should be called before such a tribunal on so scandalous and injurious an account, he would resign his office, and would refuse to answer. It came, however, before the House of Lords, 22d January 1753, on the motion of the Duke of Bedford.

The debate was long and heavy, says Lord Melcombe; the Duke of Bedford's performance moderate enough; he divided the House, but it was not told, for there went below the bar with him the Earl Harcourt, Lord Townshend, the Bishop of Worcester, and Lord Talbot only. The Bishop of Norwich and Lord Harcourt both spoke, not to much purpose; but neither of them in the least supported the Duke's question.

Upon the whole, Lord Melcombe concludes, "It was the worst judged, the worst executed, and the worst supported point that I ever saw of so much expectation."

The King, his late Majesty, viewed it in its true light; and is reported to have said, "Whatever they were when Westminster boys, they are now my very good friends." He was likewise, as we have been informed by a gentleman connected with the family of Stormont, so delighted with Mr Murray's speech in his own vindication, that he desired to have a copy of it, as a model of dignified and candid eloquence. Fawcett, the original author of the story, seems indeed to have been a very sneaking knave, totally unworthy of credit. Bishop Johnson, who was overlooked in the turmoil, excited by the supposed guilt of Murray and Stone (see STONE, in this *Suppl.*), went to Fawcett's chambers in the Temple, and desired an interview. Being told by the servant that his master was not at home, he renewed his visit very early next morning, and declared his resolution to wait till Mr Fawcett should rise, the laundress having inadvertently confessed that he was still in bed. Fawcett, upon this, left his thorny pillow with reluctance; for something sharper than thorns (says Mr Holliday) awaited him, which he could not now possibly avoid. The result of the interview produced expressions of deep contrition, together with a letter, addressed to the Lord Bishop of Gloucester, acknowledging, in the most explicit terms, that his Lordship was innocent of the charge which he had been the instrument of bringing against him.

Murray.

On the advancement of Sir Dudley Rider to the chief justiceship of the King's Bench in 1754, Mr Murray succeeded him as attorney general; and on his death, November 1756, again became his successor as chief justice, when he was created Baron of Mansfield, in the county of Nottingham, with remainder to the heirs male of his body lawfully begotten.

As soon as Lord Mansfield was established in the King's Bench, he began to make improvements in the practice of that court. On the 12th of November, four days after he had taken his seat, he made a very necessary regulation, observing, "Where we have no doubt, we ought not to put the parties to the delay and expence of a farther argument; nor leave other persons, who may be interested in the determination of a point so general, unnecessarily under the anxiety of suspence."

The anxiety of suspence, from this period, was no longer to be complained of in the court of King's Bench. The regularity, punctuality, and dispatch of the new chief justice, afforded such general satisfaction, that they, in process of time, drew into that court most of the causes which could be brought there for determination.

Sir James Burrows says, "I am informed, that at the sittings for London and Middlesex only, there are not so few as 800 causes set down in a year, and all disposed of. And though many of them, especially in London, are of considerable value, there are not more, upon an average, than between 20 and 30 ever heard of afterwards in the shape of special verdicts, special cases, motions for new trials, or in arrest of judgment. Of a bill of exceptions there has been no instance (I do not include judgments upon criminal prosecutions; they are necessary consequences of the convictions). My reports give but a very faint idea of the extent of the whole business which comes before the court: I only report what I think may be of use as a determination or illustration of some matter of law. I take no notice of the numerous questions of fact which are heard upon affidavits (the most tedious and irksome part of the whole business). I take no notice of a variety of contestations, which, after having been fully discussed, are decided without difficulty or doubt. I take no notice of many cases which turn upon a construction so peculiar and particular, as not to be likely to form a precedent for any other case. And yet, notwithstanding this immensity of business, it is notorious, that, in consequence of method, and a few rules which have been laid down to prevent delay (even where the parties themselves would willingly consent to it), nothing now hangs in court. Upon the last day of the very last term, if we exclude such motions of the term as by desire of the parties went over of course as peremptories, there was not a single matter of any kind that remained undetermined, excepting one case relating to the proprietary Lordship of Maryland, which was professedly postponed on account of the present situation of America. One might speak to the same effect concerning the last day of any former term for some years backward."

The same author also informs us, that, excepting two cases,

Murray. cases, there had not been, from the 6th of November 1756 to the time of his then present publication, 26th May 1776, a final difference of opinion in the court in any case, or upon any point whatsoever. "It is remarkable, too (he adds), that, excepting these two cases, no judgment given during the same period has been reversed, either in the exchequer chamber or in parliament: and even these reversals were with great diversity of opinion among the judges." Of the two cases here mentioned, one was the famous question concerning literary property, which the majority of the judges of the court of King's Bench held to be permanent: and in support of which opinion, such arguments were urged by the chief justice, as have not yet perhaps been completely answered.

The ill success of the war, which had lately been begun, occasioned a change in the administration; and the conflicts of contending parties rendered it impracticable for the crown, at that juncture, to settle a new ministry. In order, therefore, to give pause to the violence of both sides, Lord Mansfield was induced to accept the post of chancellor of the exchequer on the 9th of April 1757; which he held until the 2d of July in the same year. During this interval, he employed himself, with great success, to bring about a coalition; which being effected, produced a series of events, which raised the glory of Great Britain to the highest point at which it has ever been seen. In the same year he was offered, but refused, the office of Lord High Chancellor; and in November 1758, he was elected a governor of the charter house, in the room of the Duke of Marlborough, then lately deceased.

For several years after this period, the tenor of Lord Mansfield's life was marked only with a most sedulous discharge of the duties of his office. In 1760 Geo. II. died, and the new reign commenced with alterations in the administration; which gave rise to a virulent spirit of opposition, conducted with a degree of violence and asperity never known at any former time. As a friend to the then administration, Lord Mansfield was marked out for a more than ordinary share of malicious invective. It is in allusion to this, that Warburton, after tracing the rise and progress of the irreligion and licentiousness which then prevailed, and observing that, amid such general corruption, the pure administration of public justice still afforded a cheerful consolation to thinking men, proceeds thus:

"But the evil genius of England would not suffer us to enjoy it long; for, as if envious of this last support of government, he hath now instigated his blackest agents to every extent of their malignity; who, after the most villainous insults on all other orders and ranks in society, have at length proceeded to calumniate even the king's supreme court of justice, under its ablest and most unblemished administration. After this, who will not be tempted to despair of his country, and say with the good old man in the scene,

——"*Ipsa si cupiat salus*
"*Servare, prorsus non potest, hanc Familiam* (D)?"

Murray. A change of administration again took place in 1765 which introduced the Marquis of Rockingham and his friends to govern the country; and the measures then adopted not agreeing with Lord Mansfield's sentiments, he, for the first time, became an opponent of government. On the bill for repealing the stamp act, he spoke, and divided against it; and is supposed to have had some share in the composition of the protests on that occasion, though he did not sign them. In the same year, he is said to have animadverted, with no small degree of severity, on the incautious expressions of Lord Camden, on the affair of prohibiting the exportation of corn, that it was but a 40 days tyranny at the outside (E).

In 1767, the Dissenters cause was determined, in which Lord Mansfield delivered a speech, which has since been printed, and shews his Lordship to have been a steady friend to religious toleration, as well as to the rights of the established church. The conscientious Dissenters themselves lavished upon that speech the highest praise; whilst others of them, in the succeeding year, deluged the public prints with torrents of abuse on the Chief Justice. In that year was the general election. Mr Wilkes returned from abroad, became a candidate for the city of London, and afterwards was chosen representative for the county of Middlesex. Having been outlawed some years before, he now applied for a reversal of that proceeding. On the 8th of June, the consideration of it came before the court of King's Bench; when the judges delivered their opinions very fully, and were unanimous that the outlawry was illegal, and must be reversed. On this occasion, Lord Mansfield took the opportunity of entering into a full statement of the case, and a justification of his own conduct. The reader will find the case reported by Sir James Burrow, from whom we shall extract the following, which appears to have been the most important part of his Lordship's speech:

"It is fit to take some notice of the various terrors hung out; the numerous crowds which have attended, and now attend, in and about the hall, out of all reach of hearing what passes in court; and the tumults which in other places have shamefully insulted all order and government. Audacious addresses in print dictate to us, from those they call the people, the judgment to be given now, and afterwards upon the conviction. Reasons of policy are urged, from danger to the kingdom, by commotions and general confusion.

"Give me leave to take the opportunity of this great and respectable audience, to let the whole world know all such attempts are vain. Unless we have been able to find an error which will bear us out to reverse the outlawry, it must be affirmed. The constitution does not allow reasons of state to influence our judgment: God

(D) See the dedication of the 5th edition of the Divine Legation of Moses, which deserves to be read at present with peculiar attention, as the work of a man of gigantic talents, deeply read in law as well as in theology.

(E) The speeches in the debate were never printed; but the substance of them all was consolidated in a pamphlet published at the time, intituled, "A Speech against the suspending and dispensing prerogative," 8vo. Since reprinted in Debrett's Debates, Vol IV. p. 3[illegible]4.

Murray. God forbid it should! We must not regard political consequences, how formidable soever they may be; we are bound to say, *Fiat Justitia, ruat Cælum*. The constitution trusts the king with reasons of state and policy: He may pardon offences; it is his to judge whether the law or the criminal should yield. We have no election. None of us encouraged or approved the commission of either of the crimes of which the defender is convicted: none of us had any hand in his being prosecuted. As to myself, I took no part (in another place) in the addresses for that prosecution. We did not advise or assist the defender to fly from justice; it was his own act, and he must take the consequences. None of us have been consulted, or had any thing to do with the present prosecution. It is not in our power to stop it; it was not in our power to bring it on. We cannot pardon. We are to say what we take the law to be. If we do not speak our real opinions, we prevaricate with God and our own consciences.

"I pass over many anonymous letters I have received: those in print are public; and some of them have been brought judicially before the court. Whoever the writers are, they take the wrong way. I will do my duty unawed. What am I to fear? That *mendax infamia* from the press, which daily coins false facts and false motives? The lies of calumny carry no terror to me. I trust, that my temper of mind, and the colour and conduct of my life, have given me a suit of armour against these arrows. If, during this king's reign, I have ever supported his government, and assisted his measures, I have done it without any other reward than the consciousness of doing what I thought right. If I have ever opposed, I have done it upon the points themselves, without any collateral views. I honour the king, and respect the people. But many things acquired by the favour of either are, in my account, objects not worth ambition. I wish popularity; but it is that popularity which follows, not that which is run after.—It is that popularity which, sooner or later, never fails to do justice to the pursuit of noble ends by noble means. I will not do that which my conscience tells me is wrong upon this occasion, to gain the huzzas of thousands, or the daily praise of all the papers which come from the press. I will not avoid doing what I think is right, though it should draw on me the whole artillery of libels, all that falsehood and malice can invent, or the credulity of a deluded populace can swallow. I can say with a great magistrate, upon an occasion, and under circumstances not unlike, '*Ego hoc animo semper fui, ut invidiam virtute partam, gloriam, non invidiam putarem.*'

"The threats go further than abuse: Personal violence is denounced. I do not believe it: it is not the genius of the worst men of this country in the worst of times. But I have set my mind at rest. The last end that can happen to any man never comes too soon, if he falls in support of the law and liberty of his country (for liberty is synonymous to law and government). Such a shock, too, must be productive of public good: It might awake the better part of the kingdom out of that lethargy which seems to have benumbed them; and bring the mad part back to their senses, as men intoxicated are sometimes stunned into sobriety.

"Once for all, let it be understood, that no endeavours of this kind will influence any man who at present sits here. If they had any effect, it would be contrary to their intent: Leaning against their impression might give a bias the other way. But I hope, and I know, that I have fortitude enough to resist even that weakness. No libels, no threats, nothing that has happened, nothing that can happen, will weigh a feather against allowing the defendant, upon this and every other question, not only the whole advantage he is intitled to from substantial law and justice, but every benefit from the most critical nicety of form, which any other defender could claim under the like objection. The only effect I feel is an anxiety to be able to explain the grounds upon which we proceed; so as to satisfy all mankind, that a flaw of form given way to in this case, could not have been got over in any other."

In January 1770, Lord Mansfield again was offered the Great Seal, which was given to Mr Charles York: and in Hilary Term 1771, he a third time declined the same offer, and the Seal was entrusted to Lord Bathurst.

The year 1770 was also memorable for various attacks made on his Lordship's judicial character, in both the Houses of Lords and Commons. In one of these, the propriety of a direction given to the jury in the case of the king and Woodfal was called in question; which occasioned his Lordship to produce to the House a copy of the unanimous opinion of the court of King's Bench in that cause; which, after being much canvassed and opposed, was suffered to stand its ground without being over-ruled.

On the 19th of October 1776, his Lordship was advanced to the dignity of an Earl of Great Britain, by the title of the Earl of Mansfield, and to his male issue; and for want of such issue, to Louisa Viscountess Stormont, and to her heirs male by David Viscount Stormont her husband. The same title, in 1792, was limited to Lord Stormont himself; who afterwards succeeded to it.

We come now to a period of his Lordship's life, which furnishes an event disgraceful to the age and country in which the fact was committed. An union of folly, enthusiasm, and knavery, had excited alarms in the minds of some weak people, that encouragements were given to the favourers and professors of the Roman Catholic faith inconsistent with religion and true policy. The act of Parliament, which excited the clamour, had passed with little opposition, and had not received any extraordinary support from Lord Mansfield. The minds of the public were inflamed by artful misrepresentations; the rage of a popular mob was soon directed towards the most eminent persons. Accordingly, in the night between Tuesday the 6th and Wednesday the 7th of June 1780, his Lordship's house in Bloomsbury Square was attacked by a party of rioters, who, on the Friday and Tuesday preceding, had, to the amount of many thousands, surrounded the avenues of both Houses of Parliament, under pretence of attending Lord George Gordon when he presented the petition from the Protestant Association. On Tuesday evening the prison of Newgate had been thrown open, all the combustible part reduced to ashes, and the felons let loose upon the public. It was after this attempt to destroy the means of securing the victims of criminal justice that the rioters assaulted the residence of the chief magistrate of the first criminal court in the kingdom; nor were they dispersed till they had burnt all the furniture, pictures books, manuscripts, deeds, and, in short, every thing which fire could consume in his Lordship's

Murray. ship's house; so that nothing remained but the walls, which were seen next morning almost red-hot from the violence of the flames, presenting a melancholy and awful ruin to the eyes of the passengers. For a fuller account of those dreadful riots, see BRITAIN, n° 644. *Encyclopædia*.

So unexpected was this daring outrage on order and government, that it burst on Lord Mansfield without his being prepared in the slightest manner to resist it. He escaped with his life only, and retired to a place of safety, where he remained until the 14th of June, the last day of term, when he again took his seat in the court of King's Bench. "The reverential silence (says Mr Douglas) which was observed when his Lordship resumed his place on the Bench, was expressive of sentiments of condolence and respect, more affecting than the most eloquent address the occasion could have suggested.

"The amount of that part of Lord Mansfield's loss which might have been estimated, and was capable of a compensation in money, is known to have been very great. This he had a right to recover against the *hundred*. Many others had taken that course; but his Lordship thought it more consistent with the dignity of his character not to resort to the indemnification provided by the legislature. His sentiments, on the subject of a reparation from the state, were communicated to the Board of Works in a letter, dated 18th July 1780, written in consequence of an application which they had made to him (as one of the principal sufferers), pursuant to directions from the treasury, founded on a vote of the House of Commons, requesting him to state the nature and amount of his loss. In that letter, after some introductory expressions of civility to the surveyor general, to whom it was addressed, his Lordship says, 'Besides what is irreparable, my pecuniary loss is great. I apprehended no danger, and therefore took no precaution. But how great soever that loss may be, I think it does not become me to claim or expect reparation from the state. I have made up my mind to my misfortune, as I ought, with this consolation, that it came from those whose object manifestly was general confusion and destruction at home, in addition to a dangerous and complicated war abroad. If I should lay before you any account or computation of the pecuniary damage I have sustained, it might seem a claim or expectation of being indemnified. Therefore you will have no further trouble upon this from, &c.—*Mansfield*."

From this time the lustre of Lord Mansfield continued to shine with unclouded brightness until the end of his political life, unless his opposition to the measures of the present administration, at the early period of their appointment, shall be thought to detract, in some small degree, from his merit. It is certain many of his admirers saw, with concern, a connection with the opponents of government at that juncture, scarce compatible with the dignity of the chief justice of Great Britain. At length infirmities pressed upon him, and he became unable to attend his duty with the same punctuality and assiduity with which he had been accustomed. It has been supposed, that he held his office after he was disabled from executing the duties of it, from a wish to secure the succession of it to a very particular friend. Be this as it may, the chief justice continued in his office until the month of June 1788, when he sent in his resignation.

From this period the bodily powers of his Lordship continued to decline; his mental faculties, however, remained without decay almost to the last. During this time he was particularly inquisitive and anxious about the proceedings in France, and felt his sensibility, in common with every good man, wounded by the horrible instance of democratic infatuation in the murder of the innocent Louis XVI. He lived just long enough to express his satisfaction at the check given to the French by the Prince of Cobourg in March 1793; on the 20th of which month, after continuing some days in a state of insensibility, he departed this life, at the age of 88 years.

"In his political oratory (says a writer of the present times), he was not without a rival; no one had the honour of *surpassing* him; and let it be remembered, that his competitor was PITT.

"The rhetorician that addressed himself to Tully in these memorable words—*Demosthenes tibi præripuit ne primus esses Orator, tu illi ne solus*—anticipated their application to Mansfield and Pitt. If the one possessed Demosthenean fire and energy, the other was at least a Cicero. Their oratory differed in species, but was equal in merit. There was, at least, no superiority on the side of Pitt. Mansfield's eloquence was not, indeed, of that daring, bold, declamatory kind, so irresistibly powerful in the momentary bustle of popular assemblies; but it was possessed of that pure and Attic spirit, and seductive power of persuasion, that delights, instructs, and eventually triumphs. It has been very beautifully and justly compared to a river, that meanders through verdant meads and flowery gardens, reflecting in its crystal bosom the varied objects that adorn its banks, and refreshing the country through which it flows.

"To illustrate his oratory by example, would require voluminous transcripts from the records of Parliament; and it is unnecessary, as we can appeal to living recollection.

"Having added weight and dignity to the offices of attorney and solicitor general, his reputation as a speaker, a lawyer, and a politician, elevated him to the peerage, and the exalted post of chief justice of England. He ascended to the dignities of state by rapid strides: they were not bestowed by the caprice of party favour or affection. They were (as was said of Pliny) liberal dispensations of power upon an object that knew how to add new lustre to that power, by the rational exertion of his own.

"Here we can speak of this great man within our own recollection; and however party prejudices may adopt their different favourites, and each contend in detracting from the merit of the other, it is, we believe, generally understood, that precedence is allowed the Earl of Mansfield, as the first magistrate that ever so pre-eminently graced that important station. The wisdom of his decisions, and unbiassed tenor of his public conduct, will be held in veneration by the sages of the law, as long as the spirit of the constitution, and just notions of equity, continue to have existence. No man has ever, in an equal degree, possessed that wonderful sagacity in discovering chicanery and artifice, and separating fallacy from truth, and sophistry from argument, so as to hit the exact equity of the case. He suffered not justice to be strangled in the nets of form.

"His memory was astonishing—he never took notes, or,

or, if he did, seldom or ever consulted them." His references to expressions which fell from him in the course of the debate, or his quotations from books, were so faithful, that they might have been said to have been repeated *verbatim*. The purposes to which he employed these amazing talents were still more extraordinary: if it was the weak part of his opponent's arguments that he referred to, he was sure to expose its fallacy, weakness, or absurdity, in the most poignant satire, or hold it up in the most ridiculous point of view. If, on the contrary, it were a point on which his adversaries laid their chief stress, he stated the words correctly; collected their obvious meaning, considered the force of the several arguments that had or might have been raised upon them, with a precision that would induce an auditor almost to suppose that he had previously considered the whole, and that his speech was the result of much previous study.

"It may be said of Mansfield as of Virgil, that if he had any faults, they might be considered in the same manner with those of some eminent fixed star, which, if they exist at all, are above the reach of human observation. The luminous æther of his life was not obscured by any shade dark enough to be denominated a defect. On account of his descent, local prejudices and propensities were imputed to him, and his conduct, on that account, examined with a microscopic eye; but the optic through which it was viewed possessed a party tinge, equally odious and deceptive.

"His political principles were ever consistent; and to preserve consistency in such stations and in such times as occupied the life of Mansfield, constitutes an ordeal strongly impressive of virtue. It has been said that he wanted spirit. Is the uniform opposition of popular opinion, and apparently the contempt of it, any proof of the assertion? His speech and conduct in the affair of Wilkes's outlawry, when popular prejudice ran in torrents, illustrate each other. He despised (to borrow an expression of his own) that mushroom popularity that is raised without merit, and lost without a crime. He disdained being the slave of popular impulse, or to acknowledge the shouts of a mob for the trumpet of fame."

He had a mind too great to be ashamed of revering the ordinances of religion; and as, after the most impartial inquiry, he was a firm believer of the truth and importance of Christianity, he frequented the church regularly, and received the holy sacrament on the higher festivals. Mr Holliday has published a sermon, which he says was dictated by Lord Mansfield to his friend bishop Johnson, and preached by that prelate before the House of Lords. It is a very serious and appropriate discourse; but judging upon internal evidence, we should not have supposed it the composition of the eloquent and argumentative chief justice of England. His Lordship's will, which was written with his own hand, upon little more than half a sheet of paper, begins with the following elegant and pious paragraph, with which we shall conclude this sketch of his character:

"When it shall please Almighty God to call me to that state, to which, of all I now enjoy I can carry only the satisfaction of my own conscience, and a full reliance upon his mercy through Jesus Christ, I desire that my body may be interred as privately as may be: and out of respect for the place of my early education, I should wish it to be in Westminster Abbey." It was interred in Westminster Abbey, in the same vault with the Countess (who had died April 10. 1784), between the late Earl of Chatham and Lord Robert Manners.

Museum.

MUSEUM, in the language of the present day, is a building in which are deposited specimens of every object that is in any degree curious, whether such objects be natural or artificial. What the word *museum* expressed originally, has been told under that title in the *Encyclopædia*.

A complete museum contains collections of preserved beasts, birds, fishes, reptiles, &c.; models of machines; rare manuscripts; and indeed specimens of every thing necessary to illustrate physical science, to improve art, to aid the antiquarian in his researches, and to exhibit the manners and customs of men in distant ages and nations. As natural objects of uncommon size or beauty, and other rare productions, were, in the earliest periods, consecrated to the gods, the temples were, of course, the first repositories of such collections, or, in other words, the first *Museums*. This, we think, has been completely proved by Professor Beckmann *.

"When Hanno (says he) returned from his distant voyages, he brought with him to Carthage two skins of the hairy women whom he found on the Gorgades islands, and deposited them as a memorial in the temple of Juno, where they continued till the destruction of the city. The horns of a Scythian animal, in which the Stygian water that destroyed every other vessel could be contained, were sent by Alexander as a curiosity to the temple of Delphi, where they were suspended, with an inscription, which has been preserved by Ælian. The monstrous horns of the wild bulls which had occasioned so much devastation in Macedonia, were, by order of King Philip, hung up in the temple of Hercules. The unnaturally formed shoulder bones of Pelops were deposited in the temple of Elis. The horns of the so called Indian ants were shewn in the temple of Hercules at Erythræ; and the crocodile found in attempting to discover the sources of the Nile was preserved in the temple of Isis at Cæsarea. A large piece of the root of the cinnamon tree was kept in a golden vessel in one of the temples at Rome, where it was examined by Pliny. The skin of that monster which the Roman army in Africa attacked and destroyed, and which probably was a crocodile, an animal common in that country, but never seen by the Romans before the Punic war, was, by Regulus, sent to Rome, and hung up in one of the temples, where it remained till the time of the Numantine war (A). In the temple of Juno, in the island of Melita, there were a pair of elephants teeth of extraordinary size, which were carried away by Masinissa's admiral, and transmitted to that prince, who, though he set a high value upon them, sent them again back, because he heard they had been taken from a temple. The head of a basilisc was exhibited in one of the temples of Diana; and the bones of that sea monster, probably a whale, to which Andromeda was exposed, were preserved at Joppa, and afterwards brought to Rome.

* Vol. iv. p. 44.

(A) We think, with the translator of Beckmann's History, that this animal was not the crocodile, but the *Boa constrictor*. See Boa and Serpent, *Encycl.*

Rome. In the time of Paufanias, the head of the celebrated Calydonian boar was fhewn in one of the temples of Greece; but it was then deftitute of briftles, and had fuffered confiderably by the hand of time. The monftrous tufks of this animal were brought to Rome, after the defeat of Anthony, by the Emperor Auguftus, who caufed them to be fufpended in the temple of Bacchus. Apollonius tells us, that he faw in India fome of thofe nuts which in Greece were preferved in the temples as curiofities."

Though thefe curiofities were preferved in the temples for purpofes very different from thofe for which our collections are made, there can be no doubt but that they contributed to promote the knowledge of natural hiftory. If it be true, as Pliny and Strabo inform us, that Hippocrates availed himfelf of the accounts which were hung up in the temple of Æfculapius of different difeafes, and of the medicines and mode of treatment by which they were cured; it will eafily be believed, that the natural hiftorians availed themfelves, in a fimilar manner, of the various rare objects which were preferved in the temples of the other gods. This, we fee, Pliny actually did.

Suetonius informs us, that Auguftus had, in his palace, a collection of natural curiofities; and it is well known that Alexander gave orders to all huntfmen, bird catchers, fifhermen, and others, to fend to Ariftotle whatever rare animals they could procure. M. Beckmann feems to be of opinion, that the firft private mufeum was formed by Apuleius, who, next to Ariftotle and his fcholar Theophraftus, certainly examined natural objects with the greateft ardour and judgment; who caufed animals of every kind, and particularly fifh, to be brought to him either dead or alive, in order to defcribe their external and internal parts, their number and fituation, and to determine their characterifing marks, and eftablifh their real names; who undertook diftant journeys to become acquainted with the fecrets of nature; and who, on the Getulian mountains, collected petrefactions, which he confidered as the effects of Deucalion's flood.

The principal caufe why collections of natural curiofities were fcarce in ancient times, muft have been the ignorance of naturalifts in regard to the proper means of preferving fuch bodies as foon fpoil or corrupt. Some methods were indeed known and practifed, but they were all defective and inferior to that by fpirit of wine, which prevents putrefaction, and which, by its perfect tranfparency, permits the objects which are covered by it to be at all times viewed and examined. Thefe methods were the fame as thofe employed to preferve provifions, or the bodies of great men deceafed. They were put into falt brine or honey, or were covered over with wax. Thus the hippopotamus, defcribed by Columna, was fent to him from Egypt preferved in falt. The body of Agefipolis King of Sparta, who died in Macedonia, was fent home in honey; the celebrated purple dye of the ancients was preferved frefh for many years by the fame means; and at this day, when the Orientals are defirous of tranfporting fifh to any diftance, they cover them over with wax.

In thofe centuries which are ufually called the middle ages, the Profeffor finds no traces of what can be called a mufeum, except in the treafuries of emperors, kings, and princes, where, befides articles of great value, curiofities of art, antiquities, and relics, one fometimes found fcarce and fingular foreign animals, which were dried and preferved. Such objects were to be feen in the old treafury at Vienna; and in that of St Denis was exhibited the claw of a griffin, fent by a king of Perfia to Charlemagne; the teeth of the hippopotamus, and other things of the like kind. In thefe collections, the number of the rarities always increafed in proportion as a tafte for natural hiftory became more prevalent, and as the extenfion of commerce afforded better opportunities for procuring the productions of remote countries. Menageries were eftablifhed to add to the magnificence of courts, and the ftuffed fkins of rare animals were hung up as memorials of their having exifted. Public libraries alfo were made receptacles for fuch natural curiofities as were from time to time prefented to them; and as in univerfities the faculty of medicine had a hall appropriated for the diffection of human bodies, curiofities from the animal kingdom were collected there alfo by degrees; and it is probable that the profeffors of anatomy firft made attempts to preferve different parts of animals in fpirit of wine, as they were obliged to keep them by them for the ufe of their fcholars; and becaufe in old times dead bodies were not given up to them as at prefent, and were more difficult to be obtained. Private collections appear for the firft time in the 16th century; and there is no doubt (fays our author) that they were formed by every learned man who at that period applied to the ftudy of natural hiftory.

MUSHROOM, a fungus, of which fome of the principal fpecies have been defcribed in the *Encyclopædia* under the generic name AGARICUS. There is, however, one fpecies not mentioned there—the *Boletus hirfutus* of Bulliard, which is certainly worthy of notice, fince one of the French chemifts has lately extracted from it a bright, fhining, and very durable yellow dye. This pretty large mufhroom grows commonly on walnut and apple-trees. Its colouring-matter is contained in abundance, not only in the tubular part, but alfo in the parenchyma of the body of the mufhroom. In order to extract it, the mufhroom is pounded in a mortar, and the liquor thence obtained is boiled for a quarter of an hour in water. An ounce of liquor is fufficient to communicate colouring-matter to fix pounds of water. When the liquor has been ftrained, the ftuff to be dyed is put into it, and boiled for a quarter of an hour. All kinds of ftuff receive this colour and retain it; but on linen and cotton it is lefs bright. This colour may be modified, in a very agreeable manner, by the effect of mordants.

The procefs fucceeded beft on filk. When this fubftance, after being dyed, is made to pafs through a bath of foft foap, it acquires a fhining golden yellow colour, which has a perfect refemblance to the yellow of that filk employed to imitate embroidery in gold, and which has hitherto been brought from China and fold at a dear rate, as the method of dyeing it is unknown in Europe. The yellow colour extracted from this mufhroom may be employed alfo with advantage for painting in water colours as well as in oil.

MUTSUDDIES, in Bengal, writers, accountants, officers of government.

MUZCOORET, allowances to zemindars in land or money. See ZEMINDAR, *Suppl.*

NABOB,

N.

NABOB, or Nowab, a title of courteſy given in India to Mahomedans high in ſtation, particularly provincial governors.

The Sun's NADIR, is the axis of the cone projected by the ſhadow of the earth: ſo called, becauſe that axis being prolonged, gives a point in the ecliptic diametrically oppoſite to the ſun.

NAIB, a deputy.

NAKED, in architecture, as the naked of a wall, &c. is the ſurface, or plane, from whence the projectures ariſe; or which ſerves as a ground to the projectures.

NANCOWRY, or Soury, as it is ſometimes called, is one of the Nicobar iſles, and ſituated nearly in the centre of the cluſter (See Nicobar, *Encycl.*). Its length may be about eight miles, and its breadth nearly equal. The iſland of Comerty, which is near it, is more extenſive, but does not perhaps contain more ſolid land, being excavated by a very large bay from the ſea. The ſpace between theſe two iſlands forms a capacious and excellent harbour, the eaſtern entrance of which is ſheltered by another iſland, called Trikut, lying at the diſtance of about a league. The inlet from the weſt is narrow, but ſufficiently deep to admit the largeſt ſhips when the wind is fair.

The Danes have long maintained a ſmall ſettlement at this place, which ſtands on the northern-moſt point of Nancowry, within the harbour. A ſerjeant and three or four ſoldiers, a few black ſlaves, and two ruſty old pieces of ordnance, compoſe the whole of their eſtabliſhment. They have here two houſes; one of which, built entirely of wood, is their habitation; the other, formerly inhabited by their miſſionaries, ſerves now for a ſtorehouſe.

Theſe iſlands are in general woody, but contain likewiſe ſome portions of clear land. From the ſummits of their hills the proſpects are often beautiful and romantic. The ſoil is rich, and probably capable of producing all the various fruits and vegetables common to hot climates. The natural productions of this kind, which moſtly abound, are cocoa nuts, *papias*, plantains, limes, tamarinds, beetle-nuts, and the *melöri*, a ſpecies of breadfruit; yams, and other roots are cultivated and thrive; but rice is here unknown. The *mangoſtain*-tree, whoſe fruit is ſo juſtly extolled, grows wild; and pine-apples of a delicious flavour are found in the woods.

Of all the Nicobar iſles Nancowry and Comerty are ſaid to be the beſt peopled; the population of both being ſuppoſed to amount to eight hundred. The natives of Nancowry and of the Nicobar iſlands in general, live in villages on the ſea-ſhore, and never erect their habitations inland (A). Their houſes are of a circular form, and are covered with elliptical domes, thatched with graſs and the leaves of cocoa nut. They are raiſed upon piles to the height of ſix or eight feet above the ground; the floor and ſides are laid with planks, and the aſcent is by a ladder. In thoſe bays or inlets which are ſheltered from the ſurf, they erect them ſometimes ſo near the margin of the water as to admit the tide to flow under, and waſh away the ordure from below.

In front of their villages, and a little advanced in the water, they plant beacons of a great height, which they adorn with tufts made of graſs, or the bark of ſome tree. Theſe objects are diſcernible at a great diſtance, and are intended probably for landmarks; their houſes, which are overſhadowed by thick groves of cocoa nut trees, ſeldom being viſible from afar.

The Nicobareans, though indolent, are in general robuſt and well-limbed. Their features are ſomewhat like the Malays, and their colour is nearly ſimilar. The women are much inferior in ſtature to the men, but more active in all domeſtic affairs. Contrary to the cuſtom of other nations, the women ſhave the hair of their heads, or keep it cloſe cropt, which gives them an uncouth appearance, in the eyes of ſtrangers at leaſt.

The inhabitants of Nancowry perform, every year, a very extraordinary ceremony in honour of the dead. It is thus deſcribed by Lieutenant Colebrooke:

"On the anniverſary of this feſtival, if it can be ſo called, their houſes are decorated with garlands of flowers, fruits, and branches of trees. The people of each village aſſemble, dreſt in their beſt attire, at the principal houſe in the place, where they ſpend the day in a convivial manner; the men, ſitting apart from the women, ſmoke tobacco, and intoxicate themſelves; while the latter are nurſing their children, and employed in preparations for the mournful buſineſs of the night. At a certain hour of the afternoon, announced by ſtriking the *Goung*, the women ſet up the moſt diſmal howls and lamentations, which they continue without intermiſſion till about ſun-ſet; when the whole party get up, and walk in proceſſion to the burying-ground. Arrived at the place, they form a circle around one of the graves, when a ſtake, planted exactly over the head of the corpſe, is pulled up. The woman who is neareſt of kin to the deceaſed, ſteps out from the crowd, digs up the ſkull, and draws it up with her hands. At ſight of the bones, her ſtrength ſeems to fail her; ſhe ſhrieks, ſhe ſobs; and tears of anguiſh abundantly fall on the mouldering object of her pious care. She clears it from the earth, ſcrapes off the feſtering fleſh, and laves it plentifully with the milk of freſh cocoa-nuts, ſupplied by the byſtanders; after which ſhe rubs it over with an infuſion of ſaffron, and wraps it carefully in a piece of new cloth. It is then depoſited again in the earth, and covered up; the ſtake is replanted, and hung with the various trappings and imple-

(A) The great Nicobar iſland is perhaps an exception, where, it is ſaid, a race of men exiſts, who are totally different in their colour and manners. They are conſidered as the *Aborigines* of the country. They live in the interior parts among the mountains, and commit frequent depredations on the peaceable inhabitants of the coaſts.

implements belonging to the deceased. They proceed then to the other graves; and the whole night is spent in repetitions of these dismal and disgustful rites.'

"On the morning following, the ceremony is concluded by an offering of many fat swine; when the sacrifice made to the dead affords an ample feast to the living: they besmear themselves with the blood of the slaughtered hogs, and some, more voracious than others, eat the flesh raw. They have various ways, however, of dressing their meat, but always eat it without salt. A kind of paste made of the *melóri*, serves them for bread; and they finish their repast with copious potations of *taury*, an inebriating liquor."

The Nicobareans are hospitable and honest, and are remarkable for a strict observance of truth, and for punctuality in adhering to their engagements. Such crimes as theft, robbery, and murder, are unknown in these islands; but they do not want spirit to revenge their injuries, and will fight resolutely, and slay their enemies, if attacked or unjustly dealt with. Their only vice, if this failing can be so called, is inebriation; but in their cups they are generally jovial and good-humoured. It sometimes, however, happens at their feasts, that the men of different villages fall out; and the quarrel immediately becomes general. In these cases they terminate their differences in a pitched battle; where the only weapons used are long sticks, of a hard and knotty wood. With these they drub one another most heartily, till, no longer able to endure the conflict, they mutually put a stop to the combat, and all get drunk again.

NANKAR, ancient allowance to zemindars in land or money.

NANKEEN, or NAN-KING, is a well-known cotton stuff, which derives its name from the ancient capital of China (See NAN-KING, *Encycl.*). It is, however, according to Van Braam, manufactured at a great distance from that city, in the district of *Fong-kiang-fou*, situated in the south-east of the province of *Kiang-nam* upon the sea-shore. The colour of nankeen is natural, the down of which it is made being of the same yellow tinge with the cloth. The colour, as well as superior quality of this cotton, seems to be derived from the soil; for it is said that the seeds of the nankeen cotton degenerate in both particulars when transplanted to another province, however little different in its climate. The common opinion, that the colour of the stuff is given by a dye, occasioned an order from Europe, some years ago, to dye the pieces of nankeen of a deeper colour than they had at that period; and the reason of their being then paler than formerly is as follows:

Shortly after the Americans began to trade with China, the demand increased to nearly double the quantity it was possible to furnish. To supply this deficiency, the manufacturers mixed common white cotton with the brown; this gave it a pale cast, which was immediately remarked; and for this lighter kind no purchaser could be found, till the other was exhausted. As the consumption is grown less during the last three years, the mixture of cotton is no longer necessary, and nankeen is become what it was before. By keeping them two or three years, it even appears that they have the property of growing darker. This kind of stuff must be acknowledged to be the strongest yet known. Many persons have found that clothes made of it will last three or four years, although for ever in the wash. This it is that makes them the favourite wear for breeches and waistcoats both in Europe and America. The white nankeen is of the same quality, and is made of white cotton as good as the brown, and which also grows in Kiang nam.

NAPLES-YELLOW, called also *Neapolitan earth*, in Italian *Giallolino*, and in French *Jaune de Naples*, is a beautiful pigment, concerning which we have much information from the indefatigable Beckmann. "It has (says he) the appearance of an earth, is of a pale orange-yellow colour, ponderous, granulated, exceedingly friable, does not effloresce, nor become moist when exposed to the air, but when applied to the tongue seems to adhere to it. When reduced to a fine powder, it remains for some time suspended in water, but soon deposits itself at the bottom in the form of a slime. When boiled with water, the water, at least sometimes, is served to have a somewhat saline taste. It does not effervesce with acids, but is in part dissolved by aqua regia (nitro-muriatic acid). In the fire it emits no sulphureous vapour, is difficult to be fused, and by that operation undergoes no material change, only that its colour becomes somewhat redder. When fused with colourless glass, it gives it a milk-white colour, a sure proof that it contains no iron; and, with inflammable substances, there is obtained from it a regulus which has the appearance of a mixture of lead and antimony.

"This article is brought from Naples for the most part in the form of an earthy crust about three or four lines in thickness, and it sometimes retains the form of the vessel in which it has hardened. It can be procured also as a fine powder, as the colourmen keep it sometimes ready pounded for use."

About the nature of the substance called Naples yellow there has been much diversity of opinion. Most of those who have written about it, consider it as originating from fire, and as a volcanic production of Mount Vesuvius or Mount Ætna; others have pronounced it to be a natural ochre. Guettard thought it rather a kind of bole; but Pott approached nearest the truth, by asserting it to be an artificial preparation *. Fougeroux is entitled to the merit of having proved this, and of having shewn the possibility of preparing it. According to his experiments, Naples yellow will be obtained, if you boil for seven or eight hours, first over a slow and then over a strong fire, a mixture finely pulverised of twelve parts of pure white lead, one part of alum, one part of sal ammoniac, and three parts of diaphoretic antimony † (white oxyd of antimony by nitre). But before Fougeroux, who may have obtained an account of the process during his travels through Italy, a more certain process was published in the year 1758, by Giambattista Passeri, in his interesting work on the painting of earthen ware ‡. The articles to be employed, according to this author, are, "one pound of antimony, a pound and a half of lead, one ounce of *alume di feccia*, and the same quantity of common salt." I am inclined (says M. Beckmann) to think that this receipt was not unknown to Fougeroux, and that he considered *alume di feccia* to be alum. Professor Leonhardi, a man of very sound learning, has translated this expression by the word alum. I will, however, freely confess, that I consider *alume di feccia* not to mean alum, but salt of tartar, or potash. Pas-

* *Lithogeognosie*, v. ii. p. 15.

† *Mem. of the Acad. of Sciences*, 1766.

‡ *In Nuova raccolta di opusculi scientifici*, iv.

Naples, Nardus.

feri says, that the proportions may be varied different ways; and he gives six other receipts, in which he does not mention *alume di feccia*, but only *feccia*; and this word certainly means *weinhefen* or winestone (tartar). Professor Leonhardi himself seems to confirm this opinion, by saying, that Vairo, professor of chemistry at Naples, has translated "the ashes of wine lees" (*cineres infectorii*) by the words *alume di feccia*.

After Fougeroux's paper was printed, De la Lande published a receipt which he had received from the well-known prince San Severo, and in which lead and antimony only are employed; but no mention is made either of alum, tartar, or any other salt. This receipt is as follows:

Take lead well calcined and sifted, with a third part of its weight of antimony pounded and sifted also. Mix these substances well together, and sift them again through a piece of silk. Then take large flat earthen dishes, not varnished, cover them with white paper, and spread out the powder upon them to the depth of about two inches. Place these dishes in a potter's furnace, but only at the top, that they may not be exposed to too violent a heat. The reverberation of the flame will be sufficient. The dishes may be taken out at the same time as the earthen-ware, and the substance will then be found hard, and of a yellow colour. It is then pounded on a piece of marble with water, and afterwards dried for use.

The enamel-painters in Germany prepare a yellow glazing, not very different from the real Naples yellow, by a prescription, according to which, "one pound of antimony, six ounces of red lead, and two ounces of white sand, are to be fused together. The produce, which appears quite black, is to be pounded, and then fused again; and this process is to be repeated till the whole mass becomes thoroughly yellow. Half a pound of this mass is to be mixed with two ounces of red lead, and afterwards fused; and by this tedious process an orange-yellow pigment will be obtained."

All artists who speak of the use of Naples yellow, give cautions against applying iron to it, as the colour by these means becomes greenish, or at least dirty. For this reason, it must be pounded on a stone, and scraped together with an ivory spatula. It is employed chiefly in oil painting, because the colour is softer, brighter, and richer than that of ochre, yellow lead, or orpiment, and because it far exceeds these pigments in durability. It is employed in particular when the yellow ought to have the appearance of gold, and in this respect it may be prepared with gum water, and used as a water colour. A still greater advantage of it is, that it is proper for enamel painting, and on that account may be employed on porcelain or earthen ware (A). Professor Beckmann, however, recommends to artists to examine whether the oxyd prepared from wolfram, by boiling in the muriatic acid, which has a beautiful yellow colour, might not be used in the same manner as Naples yellow.

NARDUS. Under this generic term we have, in the *Encyclopædia*, given, from the *Philosophical Transactions*, a description of the plant or grass which Dr Blane considers as the spikenard of the ancients. It is our duty, in this place, to inform our readers, that Sir William Jones, in the 2d and 4th volumes of the *Asiatic Researches*, seems to have completely proved that the spikenard of Dioscorides and Galen, or *Nardus Indica*, was a very different plant from the Andropogon of Dr Blane, and that it grows in a country far distant from *Mackran*. The proofs brought by the illustrious president of the Asiatic Society, in support of his own opinion, are too numerous and circumstantial to be introduced into such a work as this. We shall therefore only give one of them; which though, when separated from the rest, it loses much of its force, must be allowed, even singly, to have great weight.

Nar Na

The true Indian spikenard is confessedly called by the Arabs *Sumbulu'l Hind*; for so they translate the name of it in Dioscorides. Now (says Sir William) I put a fair and plain question severally to three or four Mussulman physicians: "What is the Indian name of the plant which the Arabs call *Sumbulu'l Hind*?" They all answered, but some with more readiness than others, *Jatamansi*. After a pretty long interval, I shewed them the spikes (as they are called) of *Jatamansi*, and asked, what was the Arabic name of that Indian drug? They all answered readily, *Sumbulu'l Hind*. The same evidence may be obtained in this country by any other European who seeks it; and if among twelve native physicians, versed in Arabian and Indian philology, a single man should, after due consideration, give different answers, I will cheerfully submit to the Roman judgment of *non liquet*. But the *Jatamansi** evidently belongs to the natural order which Linnæus calls with the following *characters*: Plate CXX.

Calyx, scarce any; *margin*, hardly discernible. *Corolla*, one petal; *tube* somewhat gibbous; *border* five cleft. *Stamina*, three *Anthers*. *Pistula*, *Germ* beneath; one *Style* erect. *Seed*, solitary, crowned with a pappus. *Root*, fibrous. *Leaves*, hearted, fourfold; *radical* leaves petioled.

It appears therefore (continues the learned author) to be the Protean plant Valerian, a sister of the Mountain and Celtick Nard, and of a species which I should describe in the Linnean style, *Valeriana Jatamansi floribus triandris, foliis cordatis quaternis, radicalibus petiolatis*. The radical leaves, rising from the ground, and enfolding the young stem, are plucked up with a part of the root, and being dried in the sun or by artificial heat, are sold as a drug, which, from its appearance, has been called spikenard. The Jatamansi is a native of the most remote and hilly parts of India, such as NEPA'L, Marang Butan, near which Ptolemy fixes the native soil of the *Nardus Indica*. It grows erect above the surface of the ground, resembling an ear of green wheat; and when recent, it has a faint odour, which is greatly increased by the simple process of drying it.

NARES (JAMES), doctor of music, an eminent composer and teacher in that science, under whom some of the first musicians of the present day received the whole or part of their education, was the son of Mr Nares, who was, for many years, steward to Montague and Biog. Dict. new edit.

(A) In the Memoirs of the Academy of Sciences for 1767, Fougeroux has proved that the giallolino prepared by him produced on porcelain a much more beautiful colour than the Naples yellow sold in the shops.

Nares.

and Willoughby, earls of Abingdon. He was born, as well as his brother, the late Mr Juftice Nares, at Stanwell in Middlefex; the former in 1715, the latter in 1716. His mufical education he commenced under Mr Gates, then mafter of the royal chorifters; and completed it under the celebrated Dr Pepufch. Thus prepared, he officiated, for fome time, as deputy to Mr Pigott, organift of Windfor; but on the refignation of Mr Salifbury, organift of York, in 1734, was chofen to fucceed him, being then only nineteen. It is related, on undoubted authority, that, when the old mufician firft faw his intended fucceffor, he faid, rather angrily, "What! is that child to fucceed me?" which being mentioned to the organift elect, he took an early opportunity, on a difficult fervice being appointed, to play it throughout half a note below the pitch, which brought it into a key with feven fharps; and went through it without the flighteft error. Being afked why he did fo? he faid, that "he only wifhed to fhew Mr Salifbury what a child could do." His knowledge in all branches of his profeffion was equal to his practical fkill in this inftance; and, during his refidence at York, where he was abundantly employed as a teacher, and where he married, Mr Nares, by his good conduct, as well as profeffional merit, obtained many powerful friends. Among the foremoft of thefe was Dr Fontayne, the refpectable and venerable dean of York; who, when Dr Green died, towards the latter end of 1755, exerted his intereft fo fuccefsfully, that he obtained for him the united places of organift and compofer to his majefty. He removed therefore to London the beginning of 1756; and, about the fame time, was created doctor in mufic at Cambridge.

On the refignation of Mr Gates, in 1757, Dr Nares obtained alfo the place of mafter of the chorifters; which having been, for a long time, without increafe, notwithftanding the increafe of expences attending it, was, by royal favour, augmented about 1775, firft with the falary of the violift; and, on the revival of that place for Mr Crofdill, in 1777, with that of lutanift, which was annexed to it for ever. It was in this fituation that Dr Nares fuperintended the education of many pupils, who have fince become famous; particularly Dr Arnold, who, though with him only for a fhort time, was highly diftinguifhed by him for talents and application. The anthems and fervices which Dr Nares produced, as compofer to the royal chapel, were very numerous; many of them have fince been printed, and many which exift only in manufcript ftill continue to be performed in the choirs with much effect. Having been originally a mufician rather by accident than choice, with very ftrong talents and propenfities alfo for literature, Dr Nares was particularly attentive to exprefs the fenfe of the words he undertook to fet; and was the firft who attempted to compofe the Te Deum for the choir-fervice, in fuch a manner as to fet off the fentiments it contains to advantage. Before his time, it had been fet rather a regular ftrain of chaunt than to any expreffive melodies. The merits of Dr Nares were not overlooked by his royal patrons, whom he had occafionally the honour to attend in private, though not a part of his regular duty. To manifeft his refpect and gratitude for them, he compofed his dramatic ode, entitled The Royal Paftoral, the words of which were written by Mr Bellamy, author of a book, entitled Ethic Amufements.

In July 1780, Dr Nares was obliged, by declining health, to refign the care of the chorifters, in which place he was fucceeded by Dr Ayrton, his pupil and valued friend. In his fixty-eighth year, a conftitution, never robuft, gave way, and he died on February 10. 1783. Teftimony has been borne to the merits of Dr Nares by feveral writers, but more particularly by Mr Mafon, in his preface to a book of anthems, printed for the ufe of York Cathedral; and in his late Effays on Church Mufic, page 138. The late Lord Mornington, fo well known for mufical talents, frequently confulted him; and Sir John Hawkins derived advantage from his acquaintance, in the progrefs of his Hiftory of Mufic. Throughout life, he was not lefs refpected as a man than admired as a mufician; he had a vivacity that rendered his fociety always pleafing; and a generous contempt for every thing bafe, that manifefted itfelf on all proper occafions, and very juftly commanded efteem.

His printed works are thefe: 1. Eight Sets of Leffons for the Harpfichord; dedicated to the Right Hon. Willoughby Earl of Abingdon. Printed in 1748; reprinted in 1757. 2. Five Leffons for the Harpfichord, with a Sonata in fcore for the Harpfichord or Organ; dedicated to the Right Honourable the Countefs of Carlifle; publifhed in 1758 or 1759. 3. A Set of Eafy Leffons for the Harpfichord, three in number; with a dedication to the public, figned J. N. 4. A Treatife on Singing, fmall fize. 5. Il Principio; or A regular Introduction to playing on the Harpfichord or Organ. This was the firft fet of progreffive leffons publifhed on a regular plan. 6. The Royal Paftoral, a Dramatic Ode; dedicated to his Royal Highnefs the Prince of Wales; printed in fcore, with an overture and chorufes. 7. Catches, Canons, and Glees; dedicated to the late Lord Mornington. 8. Six Fugues, with Introductory Voluntaries for the Organ or Harpfichord. 9. A Concife and Eafy Treatife on Singing, with a Set of Englifh Duets for Beginners. A different work from the former fmall treatife. 10. Twenty Anthems, in fcore, for one, two, three, four, and five Voices. Compofed for the Ufe of his Majefty's Chapels Royal, 1778. 11. Six Eafy Anthems, with a favourite Morning and Evening Service, left for publication at his death, and publifhed in 1788, with a portrait and a concife account of the author. Of thefe compofitions the following fhort character is given by an eminent mufician, to whom they are all well known: "The leffons are compofed in a mafterly and pleafing ftyle; free from thofe tricks and unmeaning fucceffions of femitones, to which a good ear and found judgment never can be reconciled. The treatifes on finging contain duets compofed for the ufe of the children of the royal chapels, fuperior to any thing yet publifhed; and fuch as every teacher ought to perufe. His catches, canons, and glees, are natural and pleafing; efpecially the glee to all Lovers of Harmony, which gained the prize-medal at the catch-club in 1770. The Royal Paftoral is compofed throughout in a very mafterly manner; particularly the chorufes, with which each part concludes. This ode, containing 108 pages, was written, and all the vocal and inftrumental parts tranfcribed for performing, within twelve days. The

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six fugues, with introductory voluntaries for the organ, contain the strongest proofs of ingenuity and judgement; few, if any, have ever been written that can be preferred to them. In both sets of the anthems, the same characteristics appear; and the service of the latter very justly acquired the title of *favourite*; nor can there be any doubt that the works of this author will be admired as long as a taste for music shall subsist."

NAVIGATORS ISLANDS, an archipelago in the South Sea, discovered by Bougainville, who gave to them that name, because the natives do not pass between the different villages, which are all built in creeks and bays, but in their canoes. The Navigators Islands are ten in number; namely, *Opoun*, *Leoné*, *Fanfoue*, MAOUANA, *Oyolava*, *Calinasse*, *Pola*, *Shika*, *Ossamo*, and *Ouera*.

We have already given an account of the soil and productions of MAOUANA; and as the other islands of this cluster are equally fertile, we need not go over the same ground again. It may be proper, however, to observe, that in some of them the sugar-cane was found growing spontaneously, though its juice contained less of the saccharine substance than the sugar-cane of the West Indies, which our voyagers attributed to its growing in a richer soil and in the shade. According to Perouse, the Navigators Islands are situated about the 14th degree of south latitude, and between the 171st and 175th degrees of longitude west from Paris. In Oyolava the smoke was seen hovering over a village as over a large European town; and the number of canoes which from that island surrounded the frigates was immense. These are very ticklish vessels, and would be absolutely useless to any body but such excellent swimmers as the islanders, who are no more surprised or uneasy at their oversetting than we are at the fall of a hat. Taking up the canoe on their shoulders, they empty it of water, and then get in again, with the certainty of having the same operation to perform a second time in half an hour. Sometimes they join two canoes together by means of a cross piece of wood, in which they make a step to receive the mast; and in this way they are less liable to be overset, sometimes performing a long voyage without any such accident. It is needless to add, that these canoes are very small, generally containing only five or six persons, though some few of them may contain as many as fourteen.

The natives of the Navigators Islands are tall and well made. Their usual height is five feet nine, ten, and eleven inches; but their stature is less astonishing than the colossal proportions of the different parts of their bodies. "Our curiosity (says Perouse), which often led us to measure them, gave them an opportunity of making frequent comparisons of their bodily strength with ours. These comparisons were not to our advantage; and we perhaps owe our misfortunes (see MAOUANA in this *Suppl.*) to the idea of individual superiority resulting from repeated trials. Their countenances often appeared to express a sentiment of disdain, which I hoped to destroy, by ordering our arms to be used in their presence: but my end could only have been gained by directing them against human victims; for otherwise they took the noise for sport, and the trial for a diversion.

"Among these Indians a very small number is below the height indicated above. I have, however, measured several who were only five feet four inches, but these are the dwarfs of the country; and although their stature resembles ours, their strong and nervous arms, their broad chests, and their legs and thighs, are of a very different proportion.

"The men have the body painted or tatowed, so that any one would suppose them clad, although they go almost naked. They have only a girdle of sea-weeds encircling their loins, which comes down to their knees, and gives them the appearance of the river gods of fabulous history, whom it is customary to depict with rushes round their waist. Their hair is very long. They often twist it round their heads, and thus add to their native ferocity of countenance, which always expresses either surprise or anger. The least dispute between them is followed by blows of sticks, clubs, or paddles; and often, without doubt, costs the combatants their lives. They are almost all covered with scars, which can only be the consequence of their individual quarrels. The stature of the women is proportioned to that of the men. They are tall, slender, and not without grace; but they lose, while yet in their prime, those elegant forms, of which nature has not broken the mould among this barbarous race, but of which she appears to leave them in possession only for a moment, and with reluctance. Among a great number of women that I had an opportunity of seeing, I only observed three really pretty. The gross effrontery of the rest, the indecency of their motions, and the disgusting offers which they made of their favours, rendered them fit mothers and wives for the ferocious beings that surrounded us." Our author gives the following instance of indecent manners, which is, perhaps, without a parallel.

The young and prettiest females soon attracted the in spite of the Commodore's prohibition, endeavoured to form a connection with them, and were successful. The looks of the Europeans expressing desires which were soon divined, some old women undertook the negociation. The altar was prepared in the handsomest hut in the village, all the blinds were let down, and the inquisitive were excluded. The victim was then laid in the arms of an old man, who exhorted her, during the ceremony, to moderate the expression of her pain; while the matrons sang and howled: the ceremony being performed in their presence, and under the auspices of the old man, who served at once as priest and altar. All the women and children in the village were round the house, gently lifting up the blinds, and seeking to enjoy the sight through the smallest crevices in the mats. Whatever former navigators may have said, Perouse was convinced that, in the Navigators Islands at least, the young girls, before they are married, are mistresses of their persons, and that they are not dishonoured by their complaisance. It is even more than probable, that in marrying they are called to no account concerning their past conduct; but he had no doubt that they are obliged to be more reserved when provided with a husband.

These people cultivate certain arts with success. Under the article MAOUANA mention has been made of the elegant form which they give to their huts. It is not with such folly as is commonly supposed that they disdain our instruments of iron; for they finish their work

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Navigators. very neatly with tools made of a very fine and compact species of basaltes in the form of an adze. For a few glass beads they sold to Perouse large three legged dishes of a single piece of wood, and so well polished that they seemed to have been laid over with a coat of the finest varnish. It would take an European workman several days to produce one of these dishes, which, for want of proper instruments, must cost an Indian several months labour. They set, however, scarcely any value upon them, because they set little upon the time they employ. The fruit trees and nutritious roots that grow spontaneously around them, insure to them their subsistence, as well as that of their hogs, dogs, and fowls; and if they sometimes stoop to work, it is to procure enjoyments rather agreeable than useful. They manufacture very fine mats, and some paper stuffs. Our author remarked two or three of them, whom he took for chiefs, with a piece of cloth tied round their waist like a petticoat, instead of a girdle of weeds. It is composed of real thread, prepared no doubt from some filamentous plant like the nettle or flax; and is manufactured without a shuttle, the threads being absolutely laid over one another like those of their mats. This cloth, which has all the suppleness and solidity of ours, is very fit for the sails of their canoes; and appeared far superior to the paper stuff of the Society and Friendly Islands, which they manufacture also. Their canoes are well constructed, and furnish a good proof of the skill with which they work in wood. For a few glass beads they gave to the Frenchmen, among other things, a wooden vessel filled with cocoa nut oil, exactly of the shape of our earthen pots, and such as no European would undertake to fashion by any other means than a turning lathe. Their ropes are round, and twisted like watch chains of ribbon: their mats are very fine; but their stuffs are inferior to those of the Easter and Sandwich Islands.

Perouse derives the natives of those islands, whose colour, he says, nearly resembles that of the Algerines and other nations on the coast of Barbary, from the Malays; and as we do not vouch for the truth of his theory, though we admit it to be ingenious, we shall give the reasoning by which he supports it in his own words.

"We did not at first discover (says he) any identity between their language and that of the natives of the Society and Friendly Islands, of which we had vocabularies; but a more mature examination convinced us, that they speak a dialect of the same language. A fact which tends to prove it, and which confirms the opinion of the English concerning the origin of these people, is, that a young domestic, a native of the province of Tagayan in the north of Manilla, understood and explained to us the greater part of their words. It is well known that the Tagayan, the Talgal, and the generality of languages spoken in the Philippines, are derived from the Malay: a language more diffused than were those of the Greeks and Romans, and common to the numerous tribes that inhabit the islands of the great Pacific Ocean. It appears to me evident, that all these different nations are the progeny of Malay colonies, which, in some age extremely remote, conquered the islands they inhabit. I should not even wonder, if the Chinese and Egyptians, whose antiquity is so much vaunted, were mere moderns in comparison of the Malays. But however this may be, I am satisfied that the aborigines of the Philippine Islands, Formosa, New Guinea, New Britain, the New Hebrides, the Friendly Islands, &c. in the southern hemisphere, and those of the Marianna and Sandwich islands in the northern, were that race of woolly headed men still found in the interior of the islands of Luconia and Formosa. They were not to be subjugated in New Guinea, New Britain, and the New Hebrides; but being overcome in the more eastern islands, which were too small to afford them a retreat in the centre, they mixed with the conquering nation. Thence has resulted a race of very black men, whose colour is still several shades deeper than that of certain families of the country, probably because the latter have made it a point of honour to keep their blood unmixed. I was struck with these two very distinct races in the Islands of Navigators, and cannot attribute to them any other origin.

"The descendants of the Malays have acquired in those islands a degree of vigour and strength, a lofty stature, and a Herculean form, which they do not inherit from their forefathers, but which they owe, without doubt, to an abundance of food, to a mild climate, and to the influence of different physical causes which have been constantly acting during a long series of generations. The arts which they perhaps brought with them may have been lost for want of materials and instruments to practise them; but the identity of language, like Ariadne's clue, enables the observer to follow all the windings of this new labyrinth. The feudal government is also preserved here: that government which little tyrants may regret; which was the disgrace of Europe for several centuries; and of which the Gothic remains are still to be found in our laws, and are the medals that attest our ancient barbarism: that government, which is the most proper to keep up a ferocity of manners, because the smallest disputes occasion wars of village against village, and because wars of this nature are conducted without magnanimity, and without courage. Surprises and treachery are employed by turns; and in these unfortunate countries, instead of generous warriors, nothing is to be found but base assassins (A). The Malays are still the most perfidious nation

(A) This was written under the old government of France by a man who, like other declaimers in the cause of liberty, forgot the excellencies, and insisted only on the defects of the feudal institutions. Had Perouse, however, returned to Europe, and witnessed the *philosophic* government of his country, he would have perceived, that *liberty* and *equality*, and *the rights of man*, are as well calculated to generate base assassins, as the Gothic remains of that government by which he supposed Europe to have been so long disgraced. He might even have lived to regret, that his lot was not cast among the bold and ferocious inhabitants of Maouana; for the treachery and cruelty of these people bears no proportion, even in his affecting narrative, to the systematic cruelty of those who decreed, that the end sanctifies the means, and that nothing, however atrocious in the estimation of antiquated moralists, is to be omitted, which contributes to elevate the mean above the noble.

tion of Asia and their children have not degenerated, because the same causes have led to and produced the same effects. It may be objected, perhaps, that it must have been very difficult for the Malays to make their way from west to east, to arrive at these different islands; but the westerly winds blow as frequently as the easterly in the vicinity of the equator, along a zone of seven or eight degrees from north to south, where the wind is so variable, that it is hardly more difficult to navigate east than west. Besides, these different conquests may not have been effected at the same time: the people in question may, on the contrary, have spread themselves by little and little, and gradually have introduced that form of government which still exists in the peninsula of Malacca, at Java, Sumatra, and at Borneo, as well as in all the other countries subject to that barbarous nation."

NAZER, Nazr, Nezer, Nuzzer, Nuzzerana; a present from an inferior; fees of office.

NEBULOUS, or Cloudy, a term applied to certain fixed stars which shew a dim hazy light; being less than those of the sixth magnitude, and therefore scarcely visible to the naked eye, to which at best they only appear like little dusky specks or clouds. Through a moderate telescope, these nebulous stars plainly appear to be congeries or clusters of several little stars.

NECKAR isle, a small barren island, or rather rock, discovered by Perouse in the Pacific Ocean. Though its sterility renders it of no importance in itself, its exact situation must be interesting to navigators, who are therefore obliged to the French Commodore for having ascertained its latitude to be 23° 34′ north, and its longitude to be 166° 52′ west from Paris. From the soundings the *Neckar* seemed to be only the top or nucleus of a much more considerable island, which, probably from being composed of a soft and dissoluble substance, the sea had gradually washed away. In proportion as the frigates left the shore, the depth, which at the distance of a mile was very little, gradually increased, till, at the distance of about ten miles, no bottom was found with a line of 150 fathoms; and over the whole of that shore the bottom consisted of coral and broken shells.

NEPAL, a kingdom of India, situated to the north-east of the city of Patna, at the distance of ten or twelve days journey. Within the distance of four days journey from Nepal the road is good in the plains of Hindostan, but in the mountains it is bad, narrow, and dangerous. At the foot of the hills the country is called *Teriani*; and there the air is very unwholesome from the middle of March to the middle of November; and people in their passage catch a disorder called in the language of that country *aul;* which is a putrid fever, and of which the generality of people, who are attacked with it, die in a few days; but on the plains there is no apprehension of it. Although the road be very narrow and inconvenient for three or four days at the passes of the hills, where it is necessary to cross and recross the river more than fifty times, yet, on reaching the interior mountain before you descend, you have an agreeable prospect of the extensive plain of Nepal, resembling an amphitheatre covered with populous towns and villages: the circumference of the plain is about 200 miles, a little irregular, and surrounded by hills on all sides, so that no person can enter or come out of it without passing the mountains. Nepal.

There are three principal cities in the plain, each of which was the capital of an independent kingdom; the principal city of the three is situated to the northward of the plain, and is called *Cat'hmandu:* it contains about 18,000 houses; and this kingdom, from south to north, extends to the distance of twelve or thirteen days journey as far as the borders of Tibet, and is almost as extensive from east to west. The king of Cat'hmandu has always about 50,000 soldiers in his service. The second city to the south-west of Cat'hmandu is called *Lelit Pattan*; it contains near 24,000 houses. The third principal city to the east of Lelit Pattan is called *B'hatgan:* it contains about 12,000 families, and is the metropolis of a district which extends toward the east to the distance of five or six days journey; and borders upon another nation, also independent, called *Ciratas*, who profess no religion. Besides these three principal cities, there are many other large and less considerable towns or fortresses; one of which is *Timi*, and another *Cipoli*, each of which contains about 8000 houses, and is very populous. All those towns, both great and small, are well built; the houses are constructed of brick, and are three or four stories high; their apartments are not lofty; they have doors and windows of wood well worked and arranged with great regularity. The streets of all their towns are paved with brick or stone, with a regular declivity to carry off the water. In almost every street of the capital towns there are also good wells made of stone, from which the water passes through several stone canals for the public benefit. In every town there are large square varandas well built, for the accommodation of travellers and the public: these varandas are called *Pali;* and there are also many of them, as well as wells, in different parts of the country for public use. There are also, on the outside of the great towns, small square reservoirs of water, faced with brick, with a good road to walk upon, and a large flight of steps for the convenience of those who choose to bathe.

The religion of Nepal is of two kinds: the more ancient is professed by many people who call themselves *Baryesu;* they pluck out all the hair from their heads; their dress is of coarse red woollen cloth, and they wear a cap of the same: they are considered as people of the religious order, and their religion prohibits them from marrying, as it is with the Lamas of Tibet, from which country their religion was originally brought; but in Nepal they do not observe this rule, except at their discretion. They have large monasteries, in which every one has a separate apartment or place of abode. They observe also particular festivals, the principal of which is called *Yatra* in their language, and continues a month or longer according to the pleasure of the king. The ceremony consists in drawing an idol, which at Lelit Pattan is called *Baghero*, in a large and richly ornamented car, covered with gilt copper: round about the idol stand the king and the principal Baryesus; and in this manner the vehicle is almost every day drawn thro' some one of the streets of the city by the inhabitants, who run about beating and playing upon every kind of instrument their country affords, which make an inconceivable noise.

The

The other religion, the more common of the two, is that of the Brahmens, and is the ſame as is followed in Hindoſtan, with the difference that, in the latter country the Hindus being mixed with the Mahommedans, their religion alſo abounds with many prejudices, and is not ſtrictly obſerved; whereas in Nepal, where there are no Muſſelmans (except one Caſhmirian merchant), the Hindu religion is practiſed in its greateſt purity: every day of the month they claſs under its proper name, when certain ſacrifices are to be performed and certain prayers offered up in their temples: the places of worſhip are more in number in their towns than are to be found in the moſt populous and moſt flouriſhing cities of Chriſtendom; many of them are magnificent according to their ideas of architecture, and conſtructed at a very conſiderable expence; ſome of them have four or five ſquare cupolas, and in ſome of the temples two or three of the extreme cupolas, as well as the doors and windows of them, are decorated with gilt copper.

In the city of Lelit Pattan the temple of Baghero is more valuable, on account of the gold, ſilver, and jewels it contains, than even the houſe of the king. Beſides the large temples, there are alſo many ſmall ones, which have ſtairs, by which a ſingle perſon may aſcend, on the outſide all around them; and ſome of thoſe ſmall temples have four ſides, others ſix, with ſmall ſtone or marble pillars poliſhed very ſmooth, with two or three pyramidal ſtories, and all their ornaments well gilt, and neatly worked according to their ideas of taſte. On the outſide of ſome of their temples there are great ſquare pillars of ſingle ſtones from twenty to thirty feet high, upon which they place their idols ſuperbly gilt. The greateſt number of their temples have a good ſtone ſtaircaſe in the middle of the four ſquares, and at the end of each flight of ſtairs there are lines cut out of ſtone on both ſides: around about their temples there are alſo bells, which the people ring on particular occaſions; and when they are at prayers, many cupolas are alſo quite filled with little bells hanging by cords in the inſide about the diſtance of a foot from each other, which make a great noiſe on that quarter where the wind conveys the ſound. There are not only ſuperb temples in their great cities, but alſo within their caſtles.

To the eaſtward of Cat'hmandu, at the diſtance of about two or three miles, there is a place called *Tolu*, by which there flows a ſmall river, the water of which is eſteemed holy, according to their ſuperſtitious ideas, and thither they carry people of high rank, when they are thought to be at the point of death: at this place there is a temple, which is not inferior to the beſt and richeſt in any of the capital cities. They alſo have it on tradition, that at two or three places in Nepal valuable treaſures are concealed under ground: one of thoſe places they believe is Tolu; but no one is permitted to make uſe of them except the king, and that only in caſes of neceſſity. Theſe treaſures, they ſay, have been accumulated in this manner: When any temple had become very rich from the offerings of the people, it was deſtroyed, and deep vaults dug under ground one above another, in which the gold, ſilver, gilt copper, jewels, and every thing of value, were depoſited. This was found to be actually the caſe when the miſſionary, from whoſe memoir this account of Nepal is taken, was at Cat'hmandu. One of the kings, or pretenders to the crown, who were then at war with each other, being in the utmoſt diſtreſs for want of money to pay his troops, ordered the vaults at Tolu to be opened; and found in the firſt vault more money, beſides ſilver and gold too! than [illegible]diate occaſion for.

To the weſtward alſo of the great city [illegible] Lelit Pattan, at the diſtance of only three miles, is a caſtle called *Banga*, in which there is a magnificent temple. No one of the miſſionaries ever entered into this caſtle; becauſe the people who have the care of it, have ſuch a ſcrupulous veneration for the temple, that no perſon is permitted to enter it with his ſhoes on; and the miſſionaries, unwilling to ſhew ſuch reſpect to their falſe deities, never entered it. The author of this memoir, however, who acted as phyſician to the commandant, was of courſe admitted within the caſtle, and got a ſight of the celebrated temple, which he declares, that for magnificence he believes ſuperior to every thing in Europe.

Beſides the magnificence of the temples, which their cities and towns contain, there are many other rarities. At Cat'hmandu, on one ſide of the royal garden, there is a large fountain, in which is one of their idols called *Narayan*. This idol is of blue ſtone, crowned and ſleeping on a mattraſs alſo of the ſame kind of ſtone, and the idol and the mattraſs appear as floating upon the water. This ſtone machine is very large, being about 18 or 20 feet long, and broad in proportion, but well worked, and in good repair.

In a wall of the royal palace of Cat'hmandu, which is built upon the court before the palace, there is a great ſtone of a ſingle piece, which is about fifteen feet long, and four or five feet thick; on the top of this great ſtone there are four ſquare holes at equal diſtances from each other; in the inſide of the wall they pour water into the holes; and in the court ſide, each hole having a cloſed canal, every perſon may draw water to drink. At the foot of the ſtone is a large ladder, by which people aſcend to drink; but the curioſity of the ſtone conſiſts in its being quite covered with characters of different languages cut upon it. Some lines contain the characters of the language of the country, others the characters of Tibet, others Perſian, others Greek, beſides ſeveral others of different nations; and in the middle there is a line of Roman characters, which appears in this form, AVTOMNEW INTER LHIVERT; but none of the inhabitants have any knowledge how they came there, nor do they know whether or not any European had ever been in Nepal before the miſſionaries, who arrived there only the beginning of the preſent century. They are manifeſtly two French names of ſeaſons, with an Engliſh word between them.

There is alſo to the northward of the city of Cat'hmandu a hill called *Simbi*, upon which are ſome tombs of the Lamas of Tibet, and other people of high rank of the ſame nation. The monuments are conſtructed after various forms: two or three of them are pyramidal, very high, and well ornamented; ſo that they have a very good appearance, and may be ſeen at a conſiderable diſtance. Round theſe monuments are remarkable ſtones covered with characters, which probably are the inſcriptions of ſome of the inhabitants of Tibet whoſe bones were interred there. The natives of Nepal not only look upon the hill as ſacred, but imagine it is protected by their idols; and from this erroneous ſuppoſition never think of ſtationing troops there for the defence

defence of it, although it be a post of great importance, and only at a short mile's distance from the city. During the hostilities, however, which prevailed when our author was in the country, this sacred hill was fortified by one of the armies, who, in digging their ditches among the tombs, found considerable pieces of gold, with a quantity of which metal the corpses of the grandees of Tibet are always interred.

The kingdom of Nepal our author believes to be very ancient, because it has always preserved its peculiar language and independence. It was completely ruined, however, about thirty or forty years ago by the dissensions of its nobles, who, on the death of their sovereign, and, as it would seem, the extinction of the royal line, could not agree in their choice of a proper successor. The consequence was, that different sovereigns were set up by the nobles of different districts; and these waged war with each other, with a degree of treachery and savage atrocity that has hardly a parallel in the annals of the world Even the Brahmens, whom we are accustomed to consider as a mild and innocent people, were, in the civil wars of Nepal, guilty of the meanest and basest villanies: they brought about treaties between the rival sovereigns, and then encouraged him whom they favoured, to massacre the adherents of the other in cold blood.

NEWTON (John), an eminent English mathematician, was born at Oundle in Northamptonshire, 1622. After a proper foundation at school, he was sent to Oxford, where he was entered a commoner of St Edmund's Hall in 1637. He took the degree of bachelor of arts in 1641; and the year following was created master, among several gentlemen that belonged to the king and court, then residing in the university. At which time, his genius being inclined to astronomy and the mathematics, he applied himself diligently to those sciences, and made a great proficiency in them, which he found of service during the times of the usurpation. After the restoration of Charles II. he reaped the fruits of his loyalty; being created doctor of divinity at Oxford Sept. 1661, he was made one of the king's chaplains, and rector of Ross in Herefordshire, in the place of Mr John Toombes, ejected for nonconformity. He held this living till his death, which happened at Ross on Christmas-day 1678. Mr Wood gives him the character of a capricious and humoursome person: however that may be, his writings are sufficient monuments of his genius and skill in the mathematics. These are, 1. *Astronomia Britannica*, &c. in three parts, 1656, in 4to. 2. Help to Calculation; with Tables of Declination, Ascension, &c. 1657, 4to. 3. *Trigonometria Britannica*, in two books, 1658, *folio*; one composed by our author, and the other translated from the Latin of Henry Gellibrand. 4. *Chiliades centum Logarithmorum*, printed with, 5. Geometrical Trigonometry, 1659. 6. Mathematical Elements, three parts, 1660, 4to. 7. A perpetual Diary or Almanac, 1662. 8. Description of the Use of the Carpenter's Rule, 1667. 9. Ephemerides, shewing the Interest and rate of Money at 6 *per cent.* &c. 1667. 10 *Chiliades centum Logarithmorum, et Tabula Partium proportionalium*, 1667. 11. The Rule of Interest, or the Case of Decimal Fractions, &c. Part II 1668, 8vo. 12. School-Pastime for young Children, &c. 1669, 8vo 13. Art of practical Gauging, &c. 1669. 14. Introduction to the Art of Rhetoric, 1671. 15. The Art of Natural Arithmetic, in whole Numbers, and Fractions Vulgar and Decimal, 1671, 8vo. 16. The English Academy, 1677, 8vo. 17. Cosmography. 18. Introduction to Astronomy. 19. Introduction to Geography, 1678, 8vo *

NICOLE (Francis), a very celebrated French mathematician, was born at Paris December 23. 1683 His early attachment to the mathematics induced M. Montmort to take the charge of his education; and he opened out to him the way to the higher geometry. He first became publicly remarkable by detecting the fallacy of a pretended quadrature of the circle. This quadrature a M Mathulon so assuredly thought he had discovered, that he deposited, in the hands of a public notary at Lyons, the sum of 3000 livres, to be paid to any person who, in the judgment of the Academy of Sciences, should demonstrate the falsity of his solution. M. Nicole, piqued at this challenge, undertook the task, and exposing the paralogism, the Academy's judgment was, that Nicole had plainly proved that the rectilineal figure which Mathulon had given as equal to the circle, was not only unequal to it, but that it was even greater than the polygon of 32 sides circumscribed about the circle. The prize of 3000 livres Nicole presented to the public hospital of Lyons.

Nicole.

* Eng. Dict New ed.

The Academy named Nicole, Eleve-Mechanician, March 12. 1707; Adjunct in 1716, Associate in 1718, and Pensioner in 1724; which he continued till his death, which happened the 18th of January 1758, at 75 years of age.

His works were all inserted in the different volumes of the Memoirs of the Academy of Sciences; and are as follow: 1. A General Method for determining the Nature of Curves formed by the Rolling of other Curves upon any Given Curve; in the volume for the year 1707. 2. A General Method for Rectifying all Roulets upon Right and Circular Bases, 1708. 3. General Method of determining the Nature of those Curves which cut an Infinity of other Curves given in Position, cutting them always in a Constant Angle, 1715. 4. Solution of a Problem proposed by M. de Lagny, 1716. 5. Treatise of the Calculus of Finite Differences, 1717. 6. Second Part of the Calculus of Finite Differences, 1723. 7. Second Section of ditto, 1723. 8. Addition to the two foregoing papers, 1724. 9 New Proposition in Elementary Geometry, 1725. 10. New Solution of a Problem proposed to the English Mathematicians, by the late M. Leibnitz, 1725. 11. Method of Summing an Infinity of New Series, which are not summable by any other known method, 1727. 12. Treatise of the Lines of the Third Order, or the Curves of the Second Kind, 1729. 13. Examination and Resolution of some Questions relating to Play, 1730. 14. Method of determining the Chances at Play. 15 Observations upon the Conic Sections, 1731. 16. Manner of generating in a Solid Body all the Lines of the Third Order, 1731. 17. Manner of determining the Nature of Roulets formed upon the Convex surface of a Sphere; and of determining which are Geometric and which are Rectifiable, 1732. 18. Solution of a Problem in Geometry, 1732. 19. The Use of Series in resolving many Problems in the Inverse Method of Tangents, 1737. 20 Observations on the Irreducible Case in Cubic Equations, 1738. 21. Observations upon Cubic Equations, 1738. 22. On the Trisection of an

Nieuwland. on Angle, 1740. 23. On the Irreducible Case in Cubic Equations, 1741. 24. Addition to ditto, 1743. 25. His Last Paper upon the same, 1744. 26. Determination, by Incommensurables and Decimals, the Values of the Sides and Areas of the Series in a Double Progression of Regular Polygons, inscribed in and circumscribed about a Circle, 1747 *.

* Hutton's Dictionary.

NIEUWLAND (Peter), professor of mathematics and natural philosophy in the university of Leyden, was born at Diemermeer, a village near Amsterdam, on the 5th of November, 1764. His father, by trade a carpenter, having a great fondness for books, and being tolerably well versed in the mathematics, instructed his son himself till he attained to his eleventh year. Young Nieuwland appears to have displayed strong marks of genius at a very early period. When about the age of three, his mother put into his hand some prints, which had fifty verses at the bottom of them by way of explanation. These verses she read aloud, without any intention that her son should learn them; and she was much surprised some time after to hear him repeat the whole from memory, with the utmost correctness, on being only shewn the prints.

Before he was seven years of age he had read more than fifty different books, and in such a manner that he could frequently repeat passages from them both in prose and in verse. When about the age of eight, Mr Aeneæ at Amsterdam, one of the greatest calculators of the age, asked him if he could tell the solid contents of a wooden statue of Mercury which stood upon a piece of clock-work. "Yes (replied young Nieuwland), provided you give me a bit of the same wood of which the statue was made; for I will cut a cubic inch out of it, and then compare it with the statue." Poems which (says his eulogist) display the utmost liveliness of imagination, and which he composed in his tenth year, while walking or amusing himself near his father's house, were received with admiration, and inserted in different poetical collections.

Such an uncommon genius must soon burst through those obstacles which confine it. Bernardus and Jeronimo de Bosch, two of the first and wealthiest men at Amsterdam, became young Nieuwland's benefactors, and contributed very much to call forth his latent talents. He was taken into the house of the former in his eleventh year, and he received daily instruction from the latter for the space of four years. While in this situation he made considerable progress in the Latin and Greek languages, and he studied philosophy and the mathematics under Wyttenbach. In the year 1783 he translated the two dissertations of his celebrated instructors, Wyttenbach and de Bosch, on the opinions which the ancients entertained of the state of the soul after death, which had gained the prize of the Teylerian theological society.

From the month of September 1784 to 1785, Nieuwland resided at Leyden as a student in the university, and afterwards applied with great diligence, at Amsterdam, to natural philosophy and every branch of the mathematics, under the direction of Professor van Swinden. He had scarcely begun to turn his attention to chemistry, when he made himself master of the theory of the much-lamented Lavoisier, and could apply it to every phenomenon. He could read a work through with uncommon quickness, and yet retain in his mind the principal part of its contents. Nieuwland.

Nieuwland's attention was directed to three principal pursuits, which are seldom united; poetry, the pure mathematics, and natural philosophy. In the latter part of his life he added to these also astronomy. Among the poems which he published, his Orion alone has rendered his name immortal in Holland. Of the small essays which he published in his youth, the two following are particularly deserving of notice: 1. A Comparative View of the Value of the different Branches of Science; and, 2. The best Means to render general, not Learning, but Soundness of Judgment and Good Taste.

One of his great objects was to bring the pure mathematics nearer to perfection, to clear up and connect their different parts, and in particular to apply them to natural philosophy and astronomy. Cornelius Douwes discovered an easy method of determining the latitude of a place at sea, not by the meridian altitude of the sun, but by two observations made at any other period of the day. This method, however, being still imperfect, Nieuwland turned his thoughts towards the improvement of it, and in the beginning of the year 1789 wrote a paper on the subject, which he transmitted to M. de Lalande at Paris, from whom it met with great approbation. In the year 1792, when Nieuwland resided two months at Gotha with Major von Zach, these two learned men often conversed on this method of finding the latitude, and calculated the result of observations which they had made with a sextant and an artificial horizon. The above paper, enlarged by these observations, was inserted by Major von Zach with Nieuwland's name in the first Supplement to Bode's Astronomical Almanack, Berlin, 1793.

This, however, was not the only service which Nieuwland endeavoured to render to astronomy. It had been observed by Newton, Euler, De la Place, and others, that the axes of the planets do not stand perpendicular, but inclined, to the plane of their orbits; and Du Sejour, in his analytical treatise on the apparent motion of the heavenly bodies, considers it as highly probable that this phenomenon depends on some *physical* cause; which, however, he does not venture to assign. Nieuwland proceeded farther, and laid down principles, from which he drew this conclusion, that the above phenomenon is intimately connected with the whole system of attraction. On these principles he made calculations, the result of which was exactly equal to the angle of the inclination of the earth's axis to the plane of its orbit. Nieuwland communicated his discovery with much modesty to the celebrated Professor Damen at Leyden, who proposed some objections to it which discouraged Nieuwland, and induced him to revise his calculations with more accuracy. Major von Zach transmitted the paper which contained them to M. De la Place at Paris, and caused it to be printed also, for the opinion of the learned, in the Supplement to Professor Bode's Astronomical Almanack for the year 1793.

The writer of this article is not acquainted either with the principles which this young astronomer assumed, or with the calculations which he made from them; but if he holds gravitation to be essential to matter, and the inclination of the axes of the planets to be the necessary result of the law of gravitation, he is undoubtedly

Nieuwland. doubtedly in an error. The axes of the planets are not all equally inclined, nor does the inclination vary in exact proportion to the squares of the distances.

Nieuwland's talents and diligence soon recommended him to the notice of his country. In his twenty-second year, he was appointed a member of the commission chosen by the College of Admiralty at Amsterdam for determining the longitude and improving marine charts. On this labour he was employed eight years, and undertook also to prepare a nautical almanack, and to calculate the necessary tables. The mathematical part was in general entrusted to Nieuwland; but he assisted also his two colleagues van Swinden and van Keulen, in the departments assigned to them, with such assiduity, that most of the work published on the longitude, together with the three additional parts, were the fruits of his labour. In the second edition of the explanation of the nautical almanack, he had also the principal share; and he was the author, in particular, of the explanation of the equation of time, the method of determining the going of a time-piece, and of calculating the declination of the moon.

Soon after Nieuwland engaged in this employment, it appeared as if his destination was about to be changed. In the year 1787, he was chosen by the States of Utrecht to succeed Professor Hennert; but on account of certain circumstances this appointment did not take place. He was, however, invited to Amsterdam by the magistrates of that city, to give lectures on mathematics, astronomy, and navigation. While in this situation, he wrote his useful and excellent treatise on navigation, the first part of which was published at Amsterdam in 1793, by George Hulst van Keulen; and it is much to be wished that M. van Swinden would complete this work from the papers bequeathed to him by his deceased friend the author.

In astronomical pursuits, Nieuwland applied not only to the theoretical, but also to the practical part; and in this study he was encouraged and assisted by Major von Zach, with whom he resided some time in the course of the year 1792, and who instructed him in the proper use of the sextant. This affectionate friend published also all his observations and calculations in the before-mentioned Supplement to Bode's Astronomical Almanack.

In the year 1789, Nieuwland was chosen member of a learned society whose object was chemical experiments; and so apt was his genius for acquiring knowledge, that in a little time he made himself completely master of the theory of chemistry. A proof of this is the treatise which he read on the 24th of May 1791, in the society, distinguished by the motto of *Felix Meritis*, and which has been printed in the first part of the New General Magazine (*Niew Algemeen Magazyn*). At the same time he was able to examine the important discoveries made by the society, to assist in preparing an account of them for the press, and to publish them with sufficient accuracy in the French language. Three parts of this work appeared under the title of *Recherches Physico-chymiques*. The first part appeared in 1792, and was afterwards reprinted in the *Journal de Physique*. The second was published in 1793, and the fourth in 1794. Some letters of his on chemistry may be found also in a periodical work called *The Messenger* (*Letterbode*).

This ingenious and diligent man was of great service Nieuwland. also in the philosophical department to the above society, *Felix Meritis*, of which he had been chosen a titular member on the 25th of January 1788, and an honorary member on the 15th of March 1791. The papers for which it was indebted to him are as follows:—1. On the Newest Discoveries in Astronomy, and the Progress lately made in that Science, 1788. This is an extract from a Latin oration which he intended to deliver at Utrecht when he expected to succeed Professor Hennert.—2. On the Figure of the Earth, 1789.—3. On the Course of Comets, and the Uncertainty of the Return of the Comet now Expected, 179..—4. On the Nature of the Mathematics. The principal object of this paper was to illustrate the idea, that the mathematics may be considered as a beautiful and perfect language.—5. On the Periodical Decrease or Increase in the Light of Certain Fixed Stars, and Particularly of the Star Algol, 1790.—6. On the Solution of Spherical Trigonometry by Means of a New Instrument Invented by Le Guin, 1791. M. le Guin having transmitted to the College of Admiralty at Amsterdam an instrument which might be used with great advantage in trigonometrical operations, and by which in calculating the longitude, one could deduce the real from the apparent distance, the admiralty charged Nieuwland to examine this instrument; and he found that it might be of excellent service for the above purpose.—7. On the Relative Value or Importance of the Sciences, 1791.—8. On the System of Lavoisier, 179..—9. On the Selenotopographia of Schröder, 1793.—10. On what is Commonly Called Cultivation, Instruction, or Enlightening, 1793.

Nieuwland had applied closely to the mathematics, astronomy, and navigation, for six years; during which time he made considerable improvements in nautical charts, and filled up his vacant hours with the study of philosophy and chemistry. In the month of July 1793 he was invited to the university of Leyden, to be professor of philosophy, astronomy, and the higher mathematics, in the room of the celebrated Damen; and the admiralty of Amsterdam requested him to continue his nautical researches, which he did with great assiduity till the period of his death. The only variation which he now made in his studies related to natural philosophy, for with the mathematics he was already sufficiently acquainted. He applied therefore to the experimental part, and spared no pains nor labour to become perfect in it; which would certainly have been the case, had he not been snatched from science and his friends at the early age of thirty. He died of an inflammation in his throat, accompanied with a fever, on the 13th of November 1794.

In his external appearance, Nieuwland was not what might be called handsome, nor had he ever been at pains to acquire that ease of deportment which distinguishes those who have frequented polite company. His behaviour and conversation were however agreeable, because he could discourse with facility on so many subjects, and never wished to appear but under his real character. On the first view one might have discerned that he was a man of great modesty and the strictest morality. His father was a Lutheran, and his mother a baptist; but he himself was a member of what is called the reformed church, *i. e.* a Calvinist, and always shewed

ed the utmost respect for the Supreme Being both by his words and his actions.

NIGER, a large river in Africa, of which many erroneous accounts have been published, and among them that which we have given in the *Encyclopædia Britannica*. By Herodotus, Pliny, Ptolemy, and other ancient authors, it is uniformly said to flow from *west* to *east*, dividing Africa as the Danube divides Europe; and from the report of the Africans, the first of these authors calls it a large river abounding with crocodiles. In the twelfth century, however, Edrisi describes the Niger, which he calls the Nile of the negroes, as running from *east* to *west*, and falling into the Atlantic Ocean, and his account was universally adopted by subsequent writers, till its falsehood was discovered by the African Association. From a number of concurring reports, Major Houghton was led to believe that the course of the Niger is from *west* to *east*, according to the most ancient account; and the truth of these reports has been established beyond all controversy by Mr Park, who saw the Niger himself, and actually accompanied it for many miles in its majestic course as laid down by Herodotus.

This river rises in or near the country of MANDING (which see in this *Supplement*), between the parallels of 10 and 11 degrees of north latitude, and between the 5th and 9th degree of west longitude, which comprehends a space the most elevated of all this portion of Africa. This is evident from the opposite courses of the three great rivers which rise in it. These are the Gambia, which runs to the west north-west; the Senegal, which runs to the north-west; and the Joliba (A), or Niger, running to the east-north-east. The head of the principal branch of the Senegal river is about 80 geographical miles to the west of that of the Niger; and the head of the Gambia is again about 100 miles west of the Senegal.

Mr Park traced the Niger to Silla, a considerable town about 420 miles from its source; and it was there larger than the Thames at Westminster. But 420 miles are but a very small part of the course of the Niger, which doubtless receives many tributary streams before it reach Kassina, 700 miles farther eastward, where there is every reason to believe that it was viewed by the ancient Romans. Our traveller collected at Silla what information he could from the Moorish and Negro traders concerning the further course of this majestic stream, as well as of the kingdoms through which it runs; and the following notices he believes to be authentic:

Two short days journey to the eastward of Silla, is the town of Jenne, which is situated on a small island in the river; and is said to contain a greater number of inhabitants than Sego itself, or any other town in Bambarra. (See SEGO, *Suppl.*) At the distance of two days more, the river spreads into a considerable lake, called *Dibbie* (or the dark lake); concerning the extent of which, all the information which our author could obtain was, that in crossing it, from west to east, the canoes lose sight of land one whole day. From this lake, the water issues in many different streams, which terminate in two large branches, one whereof flows towards the north-east, and the other to the east; but these branches join at Kabra, which is one day's journey to the southward of Tumbuctoo, and is the port or shipping-place of that city. The tract of land which the two streams encircle, is called Jinbala, and is inhabited by negroes; and the whole distance by land, from Jenne to Tumbuctoo, is twelve days journey.

From Kabra, at the distance of eleven days journey, down the stream, the river passes to the southward of Houssa, which is two days journey distant from the river. Of the further progress of this great river, and its final exit, all the natives with whom Mr Park conversed seemed to be entirely ignorant. Their commercial pursuits seldom induce them to travel further than the cities of Tumbuctoo and Houssa; and as the sole object of those journeys is the acquirement of wealth, they pay but little attention to the course of rivers, or the geography of countries. It is, however, highly probable that the Niger affords a safe and easy communication between very remote nations. All our author's informants agreed, that many of the negro merchants who arrive at Tumbuctoo and Houssa, from the eastward, speak a different language from that of Bambarra, or any other kingdom with which they are acquainted. But even these merchants, it would seem, are ignorant of the termination of the river; for such of them as can speak Arabic, describe the amazing length of its course in very general terms, saying only, that they believe *it runs to the world's end*.

Major Rennel, by comparing a great many accounts of the progress of this river beyond Houssa, with the idea which prevails in that city of its termination, has shewn it to be in a very high degree probable, that the waters of the Niger have no direct communication with the sea, but that they are spread out into a great lake in Wangara and Ghana, and evaporated by the heat of the sun. See WANGARA in this *Supplement*.

NILE, the name of a celebrated river, which, as it has been described in the *Encyclopædia*, should not have been introduced into this place, did we not think ourselves bound candidly to confess that, in our opinion, its sources, at least those sources which were the objects of ancient curiosity, have never yet been seen by any European. This seems to be proved, beyond the possibility of controversy, by Major Rennel in the Appendix to Mr Park's Travels, and by Mr Browne in his account of the *Bahr-el-abiad*, and *Dar-Fur* or *Soudan*. See SOUDAN in this *Supplement*.

Mr Bruce himself acknowledges that the Nile, which waters Egypt, is the confluence of two streams, and that the western stream, which he, with others, calls *Bahr-el-abiad*, or the *white river*, is the largest of the two. Were a man therefore to travel from Cairo up the banks of the Nile in quest of its source, he would, doubtless, when he should arrive at the division of the river into two channels, continue his journey up the greater of these; for what could induce him to turn aside with the less? Not the *name*; for neither the less nor the greater has by itself the name which, in Egypt, is given to both when united. The former, which undoubtedly has its source in Abyssinia, is there called the Abay or Abavi; and, in other countries through which

(A) This is the negro name of the river, and signifies the *great water*.

Nile, Nimiquas.

which it runs, the Bahr el Afrek; the latter is, from its source to its junction with the Abay, called the Bahr el abiad. Pliny believed that the Nile came from the west; and Ptolemy says expressly that its remote source is in the *mountains of the moon*. But this Nile must be the White River, which certainly rises to the westward of Abyssinia, and, according to Abulfeda, in the mountains of Komri or Kummeri; which, in Arabic, signifies *lunar*, being the adjective of Kummer, the moon.

In perfect conformity with this ancient account of the source of the Nile, Mr Ledyard was told at Cairo by certain persons from Dar Fur, that this celebrated river has its coy fountains in their country, at the distance of 55 days journey to the westward of Sennar, which brings them to the Komri mountains of Abulfeda, who, as well as Ptolemy and Edrisi, places the head of the Nile in a quarter far removed from Abyssinia. Ptolemy has indeed mentioned both branches; and while he describes the eastern in such a way as that it cannot be taken for any other than the Abyssinian branch, or the Nile of Bruce and the Portuguese Jesuits, speaks of a larger branch flowing from a more distant source, situated to the south-west. But this can be no other than Bruce's white river, the *Bahr el abiad* of Ledyard and Browne. It is true, there is an apparent difference in the account given by these two last mentioned travellers of the country in which the Bahr el-abiad rises; but it is a difference only apparent. Ledyard was told at Cairo that it rises in Dar-Fur; Mr Browne, who resided long in Dar Fur, was there told, that the sources of the river are near to a place called *Donga*, the residence of the chief or king of an idolatrous nation to the southward of Dar-Fur. It is to be observed, however, that the slave-merchants who trade between Donga and Cairo are always attached to the Soudan or Dar-Fur caravan; and that therefore the persons who told Ledyard that the Nile rises in their country were probably from Donga, though he took them for Furians from the name of their caravan. Mr Browne informs us, that the country about Donga is very mountainous, and that in the spot where the river rises there are said to be forty distinct hills, which are called *Kumri*. From them issues a great number of springs, that, uniting into one great channel, form the Bahr el abiad, which suffers the same periodical increase and diminution as the Nile in Egypt. The people of Donga are quite naked, black, and, as we have already observed, idolaters. Major Rennel places the mountains of the moon between 5° 40′ and 8° 10′ N. Lat. and between 24° 30′ and 30° 25′ E. Long. Their latitude and longitude, as laid down by Mr Browne, are somewhat, tho' very little, different; whilst Geesh, the source of Bruce's Nile, lies between the 10th and 11th degree of N. Lat. and in about the 37th degree of E. Long.

NIMIQUAS, a nation, or, more properly, two tribes in South Africa, called by Vaillant the *Less* and *Greater* Nimiquas.

The country of the Less Nimiquas extends in longitude from the mountains of Camis to the sea on the west, *i. e.* from 15° 25′ to 18° 25′ east from London, and in latitude from 28° 12′ to 29° 36′ south. From the information which our author could collect, he thinks that the number of inhabitants throughout the whole of this tract does not exceed 6000 souls. Even this number is annually diminished by the frequent attacks of Boshmen, and the aridity of the soil. Of the BOSHMEN we have already given such an account as can leave no doubt of the destructive nature of their incursions; and the soil must be arid indeed, if it be true, as Vaillant assures us, that in the country of the Less Nimiquas rain never falls except when it thunders, and that thunder is so rare as frequently not to be heard for the space of a whole year.

For this want of rain our author accounts in a satisfactory manner: "The country (he says) having neither forests nor lofty mountains to arrest the clouds, those which come from the north pass freely over it, and proceed on to Camis, where they burst and fall, either in rain in the valleys, or in snow on the summits of these mountains, which are the loftiest throughout the south of Africa." The country is of course not fruitful, and its sterility obliges the inhabitants frequently to change their residence, so that they are the most wandering of all the Hottentot tribes. In this barren region the Dutch colonists suppose that gold mines may be found; but our author discovered among the hordes no traces of this metal, though he found many indications of rich copper mines.

The Less Nimiquas, though of a tolerable stature, are not so tall as their neighbours to the eastward; and indeed Vaillant affirms, that the people to the east in the southern part of Africa are much superior to those of the west both in moral and physical qualities, while the animals are far inferior. The Less Nimiquas are great believers in witchcraft; and our author gives a ridiculous account of an interview that he had with an old witch named *Kakoes*, who had a complete ascendency, not only over the whole horde, but also over the savage Boshmen. These robbers, he says, never attempted to plunder the territory where she took up her residence; and she has been known, when their thefts came to her knowledge, to proceed alone, and unguarded, to their retreats in the midst of the woods, to threaten them with her vengeance, and thus compel them to a restitution of the stolen property. All her influence, however, over her own tribe, could procure for our author and his attendants only six sheep.

The women of the horde received his Hottentots with great kindness; and permitted them to discover very singular charms, of which it is needless here to insert a description. Among this people he saw abundance of bracelets, necklaces, and ear-rings of copper; and some of these ornaments were so well made and finely polished, that they must have been manufactured in Europe, and the fruits of an intercourse with the whites. But he saw several others, which, from their grotesque shape and rude workmanship, evidently shewed that they were fabricated by the savages themselves.

"These ornaments (says he) are worn by the Nimiquas in the same manner as by the other savages: yet I observed among them some whimsical peculiarities. I have seen persons with six ear-rings of the same shape in one ear, and none in the other: I have seen some with bracelets from the wrist to the elbow on one arm, while the other arm was bare: I have seen others with one side of the face painted in compartments of various colours, while on the other side both the colours and figures were different. In general, I observed a great propensity to ornaments among the Less Nimiquas,

Nimiquas. for their krosses and all their garments were plentifully covered with glass and copper beads, strung on threads, and fastened on every part of their dress. They even wore them in their hair, which was plastered with grease in the most disgusting manner. Many had their heads covered with a reddish incrustation, composed of grease and a powder resembling brick dust, with which their hair was so pasted together, that you would have sworn it to be a cap of red mortar. Those who had it in their power to display this luxury of dress, were as proud as are our *petits maitres*, when they can shake a head loaded with powder, perfume, and pomatum. The *nuyp kros*, or short apron, of the women, was adorned with rows of glass beads hanging down to their feet; in other respects they were dressed like the other Hottentots."

The country of the *Greater Nimiquas* is placed by the author in nearly the same longitude with that of the Less, and between 25° and 28° south latitude. It is barren like the other; but the people are much taller, being generally about five feet ten inches high. The men are dull and stupid, but the women are lively and extremely amorous; and both men and women are comparatively handsome and of a slender make. Extravagantly addicted to smoking tobacco, the young girls bartered their favours for a single pipe; and as Vaillant was chief of the caravan, a white, and possessor of tobacco of much better quality, many advances were made to him. "I have do doubt (says he) but I might have formed, for a few pipefuls only, an alliance with every family in the horde. I was even pressed so closely, as to be obliged to employ some resistance: but, at the same time, I must confess, that my refusals were given in such a way as not to offend; and they who, in consequence of their advances, had been exposed to them, having soon found other arrangements to make, did not shew me the less friendship. I must here add that the girls alone appeared to me thus free; while the married women on the contrary were modest and reserved. This is a characteristic difference, which distinguishes the Greater Nimiquas from the Hottentot people in general; as likewise does the low cringing air they assume when they have any thing to ask."

It has been said by Kolben, that the Nimiqua women, when they bear twins, destroy one of the infants; but Vaillant assures us that this is a falsehood, as is likewise another tale which is current in the colony. It has been said that the fathers, to shew what affection they bear their children, feed their eldest in a particular manner, as being of right the first object of paternal care. For this purpose they put him in a coop as it were; that is, they shut him up in a trench made under their hut, where, being deprived of motion, he loses little by perspiration, while they feed and cram him in a manner with milk and grease. By degrees the child fattens, and gets as round as a barrel; and when he is come to such a state as not to be able to walk, but to bend under his own weight, the parents exhibit him to the admiration of the horde; who from that period conceive more or less esteem and consideration for the family, according as the monster has acquired more or less rotundity.

Such was the account given to our author by a man who affirmed that he had been an eye witness of this mode of cramming the heir-apparent; but whenever any questions were asked on the subject of the Nimiquas themselves, the persons addressed were ready to laugh in our author's face. "Still (says he), as it appeared strange to me, that a man should talk of what he had seen, when he had in reality seen nothing; as it was possible that the fable might have some foundation, without being true in all particulars—I was willing to convince myself what could have given rise to it; and every time I visited a horde, I took care, under different pretences, to examine, one after another, all the huts of the kraal, and to ask which was the eldest child of the family: but I nowhere saw any thing that indicated either this pretended coop, or this pretended cramming." Nimiquas, Nizolius.

The Nimiquas are great cowards; yet, like the surrounding nations, they have their assagays and poisoned arrows; and, like them, can handle these arms with dexterity. They possess also those war oxen, so formidable in battle, and so favourable to the cowardice or inactivity of the combatants. They have even a peculiar implement of war, which their neighbours have not. This is a large buckler, of the height of the person who bears it, behind which the Nimiqua can completely conceal himself. But, beside that his natural apathy prevents him from giving or taking offence, he is in reality pusillanimous and cowardly from the coldness of his disposition. To utter only the name of *Houzouana* before him is sufficient to make him tremble. See HOUZOUANAS in this *Suppl.*

Notwithstanding his frigidity, the Nimiqua is not insensible to pleasure. He even seeks with avidity those which, requiring but little exertion, are capable of agitating him and procuring agreeable sensations. Their musical instruments are the same as those of the other Hottentots; but their dancing is very different, and resembles the temper of the nation. If the countenance have received from nature features that can express our passions, the body also has its attitudes and movements that paint our temper and feelings. The dance of the Nimiqua is frigid like himself, and so devoid of grace and hilarity, that, were it not for the extreme gaiety of the women, it might be called the dance of the dead.

These tortoises, to whom dancing is a fatigue, shew little eagerness for any thing but wagers, games of calculation and chance, and all the sedentary amusements which require patience and reflection, of which they are more capable than they are of motion. When our author, with great propriety, prohibited gaming in his camp, the Nimiquas, who had staid long with him, took their departure.

NITTA, a species of the MIMOSA, which flourishes on the banks of the Senegal in Africa. It is valuable to the inhabitants for its fruit, the pods of which are long and narrow, containing a few black seeds enveloped in a fine mealy powder, of a bright yellow colour, which resembles the flour of sulphur, and has a sweet mucilaginous taste. When eaten by itself it is clammy; but when mixed with milk or water, it constitutes a very pleasant and nourishing food, supplying the place of corn to the negroes.—*Park's Travels.*

NIZOLIUS (Marius), a grammarian of Italy, who by his wit and erudition contributed much to the promotion of letters in the 16th century. He published, in 1553, *Lib.* 4. *De veris Principiis et vera Ratione philoso-*

al philosophandi, contra Pseudo philosophos. In this work he attacks, with much vivacity, the schoolmen, not only for the barbarism of their terms, but for many ridiculous opinions which they held. Leibnitz was so struck with its solidity and elegance, that, to expose the obstinacy of those who were zealously attached to Aristotle, he gave a new edition of it, with critical notes of his own, 1670, in 4to. Nizolius published also, *Thesaurus Ciceronianus, sive Apparatus Linguæ Latinæ e Scriptis Tullii Ciceronis collectus*, in folio. This is a good Latin dictionary, composed of the words and expressions of Cicero; to which, it seems, Nizolius shewed as much bigotry as the schoolmen to their notions; and fell under the character of those pedants

Biog. Dictionary. whom Erasmus has ridiculed in his *Ciceronianus*. We do not find the year either of his birth or death.

NOCTURNAL ARCH, is the arch of a circle described by the sun, or a star, in the night.

Nonagesimal || Nuel. NONAGESIMAL, or NONAGESIMAL *Degree*, called also the *Mid heaven*, is the highest point, or 90th degree of the ecliptic, reckoned from its intersection with the horizon at any time; and its altitude is equal to the angle that the ecliptic makes with the horizon at their intersection, or equal to the distance of the zenith from the pole of the ecliptic. It is much used the calculation of solar eclipses.

NONAGON, a figure having nine sides and angles. In a regular nonagon, or that whose angles and sides are all equal, if each side be 1, its area will be 6·1818242 = $\frac{9}{4}$ of the tangent of 70°, to the radius 1.

NORMAL, is used sometimes for a perpendicular.

NUEL, or NEWEL, the upright post about which stairs turn, being that part of the staircase which sustains one end of the steps.

O.

Oasis || Occident. OASIS (plur. OASES), a fertile spot in the midst of a sandy desart. In the SAHARA, or Great Desart of Africa, there are many *Oases* of extreme fertility.

OBLATE, flatted or shortened; as an oblate spheroid, having its axis shorter than its middle diameter; being formed by the rotation of an ellipse about the shorter axis.

OBLIQUE ASCENSION, is that point of the equinoctial which rises with the centre of the sun, or star, or any other point of the heavens, in an oblique sphere.

OBLIQUE *Circle*, in the stereographic projection, is any circle that is oblique to the plane of projection.

OBLIQUE *Descension*, that point of the equinoctial which sets with the centre of the sun, or star, or other point of the heavens, in an oblique sphere.

OBLIQUE *Force*, or *Percussion*, or *Power*, or *Stroke*, is that made in a direction oblique to a body or plane. It is demonstrated, that the effect of such oblique force, &c. upon the body, is to an equal perpendicular one, as the sine of the angle of incidence is to radius.

OBLONG SPHEROID, is that which is formed by an ellipse revolved about its longer or transverse axis; in contradistinction from the *oblate spheroid*, or that which is flatted at its poles, being generated by the revolution of the ellipse about its conjugate or shorter axis.

OBSERVATORY, PORTABLE. See ASTRONOMY, n° 504, *Encycl.*

OCCIDENT EQUINOCTIAL, that point of the horizon where the sun sets, when he crosses the equinoctial, or enters the sign Aries or Libra.

OCCIDENT *Estival*, that point of the horizon where the sun sets at his entrance into the sign Cancer, or in our summer when the days are longest.

OCCIDENT *Hybernal*, that point of the horizon where the sun sets at midwinter, when entering the sign Capricorn.

Oct. | OCTANT, the eighth part of a circle.

ODD, in arithmetic, is said of a number that is not even. The series of odd numbers is 1, 3, 5, 7, &c.

ODDLY ODD. A number is said to be oddly odd, when an odd number measures it by an odd number. So 15 is a number oddly odd, because the odd number 3 measures it by the odd number 5.

ODOUR, that quality of certain bodies which excites the sensation of smell. In the *Annales de Chimie*, Vol. XXI. p. 254, we have a detailed account of certain experiments made by M. Benedict Prevost of Geneva, with a view to render the *emanations of odorant bodies perceptible to sight*. The account is by much too long for a work like ours; especially as we feel not ourselves inclined to attribute to the experiments all the importance which seems to have been allowed to them by the first class of the French National Institute. We shall therefore state only a few of them, which seem most to favour the author's hypothesis.

1. A concrete odorant substance, laid upon a wet glass or broad saucer, covered with a thin stratum of water, immediately causes the water to recede, so as to form a space of several inches around it.

2. Fragments of concrete odorant matter, or small morsels of paper or cork, impregnated with an odorant liquor, and wiped, being placed on the surface of water, are immediately moved by a very swift rotation. Romieu had made this observation on camphor, and erroneously attributed the effect to electricity. The motion was perceptible even in pieces of camphor of seven or eight gros.

3. An odorant liquor being poured on the water, stops the motion till it is dissipated by evaporation. Fixed oil arrests the motion for a much longer time,

Odour. and until the pellicle it forms on the water is taken off.

4. When the surface of the water is cleaned by a leaf of metal, of paper, or of glass, plunged in and withdrawn successively until the pellicle is removed, the gyratory motion is renewed. If a piece of red wax or of taper be dipped in water, and the drops shaken off into a glass of water containing odorant bodies in motion, the movement will be stopped. The same effect is not produced by metal.

5. A morsel of camphor, plunged to the depth of three or four lines in water, without floating, excites a movement of trepidation in the surrounding water, which repels small bodies in its vicinity, and carries them again to the camphor by starts The author concludes, that an elastic fluid escapes from the odorant body in the manner of the fire of a fusee or the discharge of fire arms.

6. When there is a certain proportion between the height of the water and that of the small fragment of camphor, the water is briskly driven off, returns again to the camphor, and again retires, as if by an explosion, the recoil of which often causes the camphor to make part of a revolution on its axis.

7. Camphor evaporates thirty or forty times more speedily when placed upon water, than when entirely surrounded with air.

8. Camphor, during the act of dissipation in the air, preserves its form and its opaque whiteness; upon water it is rounded, and becomes transparent as if it had undergone a kind of fusion. It may be inferred, that this arises from the acquired motion, which causes it to present a greater surface to the air.

9. When small pieces of camphor are plunged in water, the camphor becomes rounded and transparent, does not acquire any motion, and its dissipation is less perceptible than in the air. The concurrence of air and water is therefore necessary to disengage the fluid which is the cause of the motion and total dissipation of odorant bodies.

10. The motion of odorant bodies upon water decays and ceases spontaneously at the end of a certain time; because the water having then contracted a strong smell, the volatilization takes place in all the points of its surface; and the small mass being thus surrounded by the odorant fluid, which is no longer air, dissolves, as in the ordinary odorant fluids, without forming the gaseous jet which is the cause of the motion. The author compares the volatilization of the aromatic substance to a combustion excited by water.

M. Prevost hopes, that these, and other experiments which he explains, will contribute to the theory of odours, which so nearly resembles that of the gases. He does not flatter himself with having exhausted this subject, but considers his discoveries as the means of rendering odour perceptible by water, not only to the sight, but even to the touch, as are likewise the vibrations of sonorous bodies. Men deprived of the sense of smell, and even the blind according to him, may in this manner distinguish odorant bodies from those which have no smell. "Perhaps (says he) this kind of odoroscope may, by improvement, become an odorimeter. The exceptions, such for example as that of the cerumen of the ears, which produces much effect on water without being perceptibly odorant, and that of the fingers when hot or moist, are merely apparent; for if Odour. our senses do not in those cases discover odour, those of animals more powerfully energetic, such as the dog, perceive and distinguish individuals by its peculiar character. The odoroscope may afford the information which is wanting respecting these effluvia. Thus it is that the fat of game, the smell of which is nearly to us imperceptible, is very much so to dogs, and exhibits sensible marks by the odoroscope."

Professor Venturi of Modena, who heard Prevost's memoir read in the National Institute, had himself made some experiments with camphor kept separately in the air, in the water, and at the surface of the water; whence he deduces, that the most active virtue for dissolving camphor resides at that part where both the air and the water touch the camphor at the same time. Hence he explains why, in like circumstances, camphor evaporates more quickly in a moist than in a dry air; and why the Hollanders use water in their process for subliming this substance.

It might be thought that the camphor was decomposed at the surface of the water; that the water might seize the acidifying part, which renders the camphor concrete; and that the volatile part is dissipated in the atmosphere. The author rejects this notion. He thinks that water with camphor floating on its surface becomes charged with no more than a very small portion: 1. Because in these circumstances the water acquires the same taste and smell of camphor as it obtains when a small quantity of this substance is kept plunged in the same fluid. This water, by exposure to the air, loses the qualities with which it had been charged, and becomes insipid, and without smell. 2. Because when the water is saturated with all it can take up, the dissipation of the camphor continues at its surface as before. 3. Because the aerial emanations of camphor made at the surface of water do themselves crystallize into camphor.

Camphor at the surface of the water does nothing, therefore, but dissolve; and when dissolved at the ordinary temperature of the atmosphere, it is not at first in the state of vapour, as has been thought. It is simply a liquid which extends itself over the surface of water itself; and by this means coming into contact with a great surface of air, it is afterwards absorbed and evaporated. This is proved by the following facts: 1. The solution of camphor at the surface of water is more rapid in proportion to the extent of the surface. In narrow vessels, the section of the column would not be completed in ten days, even though the water might be extremely pure. 2. When the column of camphor has projecting parts, the liquid may be seen issuing by preference from certain points of the column, covering the surface of the water, and driving small floating bodies before it, in the same manner as floating bodies go and return in a bason into which the water of a canal enters with rapidity. 3. If a small piece of camphor, already wetted at one end, be brought near the edge of water contained in a broad saucer, and be made to touch the saucer itself, it deposits a visible liquor, which is oily; and by attaching itself to the saucer, destroys the adhesion between the vessel and the border of the water, so that the water retires on account of the affinity of aggregation, which not being opposed by the attraction of the saucer, causes the water to terminate in a round edge.

Odour, Œconomists.

edge. If you remove the piece of camphor, the water will not return to its place until the oily fluid is evaporated. 4. In the same manner, when the column of camphor is half immersed in the water, the oily liquor which issues forth destroys the adhesion of the water to the column, and produces a small surrounding cavity. The solution stops, or is retarded for a moment, until the fluid, extending itself over the water, becomes evaporated: the water then returns to its place, and touches the same part of the camphor; the solution begins again, and in this manner the process is effected by alternations of contact and apparent repulsion."

Of these memoirs by Prevost and Venturi, the English reader will find accurate and full translations in the first volume of *Nicholson's Philosophical Journal*, together with some judicious observations on them by the editor, which we shall take the liberty to adopt. "The philosophical consideration of odorant bodies is somewhat obscured by the old method of generalising, or referring the properties of bodies to some distinct principle or thing supposed capable of being separated from the body itself. Thus the odours of bodies have been supposed to depend on a substance imagined in a loose way to be common to them all and separable from them. Hence the terms, principle of smell, spiritus rector, and even in the modern nomenclature we find *aroma*. There does not in effect seem to be any more reason to infer the existence of a common principle of smell than of taste. The smell of ammoniac is the action of that gas upon the organ of sense; and this odorant invisible matter is exhibited to the sight when combined wit' an acid gas. But in the same manner as ammoniac emanates from water, and leaves most part of that fluid behind, so will the volatile parts of bodies be most eminently productive of this action; and very few, if any, natural bodies will be found which rise totally. The most striking circumstance in the effect is, that an act of such power should be attended with a loss by exhalation which is scarcely to be appreciated by weight, or in any other method during a short interval of time. But we know so little of nervous action, and of other phenomena of electricity, of galvanism (See GALVANISM in this *Suppl.*), or even of heat, which strongly affect the senses, but elude admeasurement by gravitation, that the difficulty of weighing the effluvia of odorant bodies becomes less astonishing."

ŒCONOMISTS, a sect of philosophers in France, who have made a great noise in Europe, and are generally believed to have been unfriendly to religion. The founder of this sect was a *Dr Duquesnai*, who had so well insinuated himself into the favour of Louis XV. that the king used to call him his *thinker*. The sect was called *œconomists*, because the œconomy and order to be introduced into the finances, and other means of alleviating the distresses of the people, were perpetually in their mouths. The Abbé Barruel admits, that there may have been some few of them who directed their speculations to no other object; but he brings very sufficient proof that the great aim of the majority of the sect was to eradicate from the minds of the people 'l reverence for divine revelation.

"Duquesnai (says he) and his adepts had more especially undertaken to persuade their readers, that the country people, and mechanics in towns, were entirely destitute of that kind of instruction necessary for their professions; that men of this class, unable to acquire knowledge by reading, pined away in an ignorance equally fatal to themselves and to the state; that it was necessary to establish free schools, and particularly throughout the country, where children might be brought up to different trades, and instructed in the principles of agriculture. D'Alembert, and the Voltairean adepts, soon perceived the advantages they could reap from these establishments. In union with the œconomists, they presented various memorials to Louis XV. in which not only the temporal but even the spiritual advantages of such establishments for the people are strongly urged. The king, who really loved the people, embraced the project with warmth. He opened his mind on the subject to Mr Bertin, whom he honoured with his confidence, and had entrusted with h purse;" and it was with great difficulty that this minister could convince him of the dangerous designs of the sect.

"Determined (says he) to give the king proof that the œconomists imp upon him. I ought to gain the confidence of those pedla ho travel through the country, and expose their goods to sale in the villages, and at the gates of country seats I suspected those in particular who dealt in books to be nothing less than the agents of philosophism with the good country folks. In my excursions into the country I fixed my attention above all on the latter. When they offered me a book to buy, I questioned them what might be the books they had? Probably catechisms or prayer-books? Few others are read in the villages? At these words I have seen many smile. No, they answered, those are not our works; we make much more money of Voltaire, Diderot, and other philosophic writings. What! said I; the country people buy Voltaire and Diderot? Where do they find the money for such dear works? Their constant answer was, we have them at a much cheaper rate than prayer-books; we can sell them at ten sols (5d.) a volume, and have a pretty profit into the bargain. Questioning some of them still farther, many of them owned that those books cost them nothing; that they received whole bales of them without knowing whence they came, but being simply desired to sell them in their journeys at the lowest price."

"Louis XV. warned by the discovery made by his minister, was at length satisfied that the establishment of these schools, so much urged by the conspirators, would only be a new instrument of seduction in their hands. He abandoned the plan; but, perpetually harassed by the protecting sophisters, he did not strike at the root of the evil, and but feebly impeded its progress. The pedlars continued to promote the measures of the conspirators; yet this was but one of the inferior means employed to supply the want of their free schools, as a new discovery brought to light one far more fatal.

"About the middle of the month of September 1789, little more than a fortnight antecedent to the atrocious 5th and 6th of October, at a time when the conduct of the National Assembly, having thrown the people into all the horrors of a revolution, indicated that they would set no bounds to their pretensions, Mr Le Roy, lieutenant of the King's Hunt, and an academician, being at dinner at the house of Mr D'Angevilliers, intendant of the buildings of his majesty, the

conversation turned on the disasters of the revolution, and on those that were too clearly to be foreseen. Dinner over, the nobleman above mentioned, a friend of Le Roy, hurt at having seen him so great an admirer of the sophisters, reproached him with it in the following expressive words: *Well! this, then, is the work of Philosophy!* Thunderstruck at these words—Alas! cried the academician, *to whom do you say so? I know it but too well, and I shall die of grief and remorse!* At the word *remorse*, the same nobleman questioned him whether he had so greatly contributed towards the revolution as to upbraid himself with it in that violent manner? 'Yes (answered he), I have contributed to it, and far more than I was aware of. I was secretary to the committee to which you are indebted for it; but I call heaven to witness, that I never thought it would go to such lengths. You have seen me in the king's service, and you know that I love his person. I little thought of bringing his subjects to this pitch, *and I shall die of grief and remorse!*'

"Pressed to explain what he meant by this committee, this secret society, entirely new to the whole company, the academician returned: 'This society was a sort of club that we philosophers had formed among us, and only admitted into it persons on whom we could perfectly rely. Our sittings were regularly held at the Baron D'Holbach's. Lest our object should be surmised, we called ourselves œconomists. We created Voltaire, though absent, our honorary and perpetual president. Our principal members were D'Alembert, Turgot, Condorcet, Diderot, La Harpe, and that Lamoignon, keeper of the seals, who on his dismission shot himself in his park.'

"The whole of this declaration was accompanied with tears and sighs; when the adept, deeply penitent, continued: 'The following were our occupations; the most of those works which have appeared for this long time past against religion, morals, and government, were ours, or those of authors devoted to us. They were all composed by the members or by the orders of the society. Before they were sent to the press, they were delivered in at our office. There we revised and corrected them; added to, or curtailed them, according as circumstances required. When our philosophy was too glaring for the times, or for the object of the work, we brought it to a lower tint; and when we thought that we might be more daring than the author, we spoke more openly. In a word, we made our writers say exactly what we pleased. Then the work was published under the title or name we had chosen, the better to hide the hand whence it came. Many, supposed to have been posthumous works, such as *Christianity Unmasked*, and divers others *attributed to Freret and Boulanger* after their deaths, were issued from our society.

'When we had approved of those works, we began by printing them on fine or ordinary paper, in sufficient number to pay our expences, and then an immense number on the commonest paper. These latter we sent to hawkers and booksellers free of cost, or nearly so, who were to circulate them among the people at the lowest rate. These were the means used to pervert the people, and bring them to the state you now see them in. I shall not see them long, *for I shall die of grief and remorse!*'

This recital is too well authenticated to be called in question, and too plain to need a commentary. Let it be a warning against all secret societies, by whatever title of benevolence they may be designed by those who form them.

OIL MILL, a mill for expressing the oils from fruits, or grains, &c. As these kingdoms do not produce the olive, it would be needless to describe the mills which are employed in the southern parts of Europe. We shall content ourselves, therefore, with a description of a Dutch oil mill, employed for grinding and pressing lintseed, rape seed, and other oleaginous grains. Farther, to accommodate our description still more to our local circumstances, we shall employ water as the first mover, thus avoiding the enormous expence and complication of a windmill. Oil.

In Plate XXXVIII. fig. A,

1. Is the elevation of a wheel, over or undershot, as the situation may require.

2. The bell metal socket, supported by masonry, for receiving the outer gudgeon of the water wheel.

3. The water course.

Fig. B.

1. A spur wheel upon the same axis, having 52 teeth.

2. The trundle that is driven by N° 1. and has 78 staves.

3. The *wallower*, or axis for raising the pestles. It is furnished round its circumference with *wipers* for lifting the *pestles*, so that each may fall twice during one turn of the water wheel, that is, three *wipers* for each pestle.

4. A frame of timber, carrying a concave half cylinder of bell-metal, in which the wallower (cased in that part with iron plates) rests and turns round. It will be seen in profile, fig. G.

5. Masonry supporting the inner gudgeon of the water wheel and the above-mentioned frame.

6. Gudgeon of the wallower, which bears against a bell metal step fixed in the wall. This double support of the wallower is found to be necessary in all mills which drive a number of heavy stampers.

Fig. C, Is the elevation of the pestle and press-frame, their furniture, the mortars, and the press-pestles.

1. The six pestles.

2. Cross pieces between the two rails of the frame, forming, with these rails, guides for the perpendicular motion of the pestles.

3. The two rails. The back one is not seen. They are checked and bolted into the standards N° 12.

4. The tails of the *lifts*, corresponding to the wipers upon the wallower.

5. Another rail in front, for carrying the *detents* which hold up the pestles when not acting. It is marked 14 in fig. M.

6. A beam a little way behind the pestles. To this are fixed the pulleys for the ropes which lift and stop the pestles. It is represented by 16 in fig. M.

7. The said pulleys with their ropes.

8. The *driver*, which strikes the wedge that presses the oil.

9. The *discharger*, a stamper which strikes upon the inverted wedge, and loosens the press.

10.

Oil 10. The lower rail with its cross pieces, forming the lower ... of the pe"

11. A small cog wheel upon the wallower, for turning the *spatula*, which stirs about the oil-seed in the *chauffer pan*. It has 28 teeth, and is marked N° 6 in fig. M.

12. The four standards, mortised below into the *block*, and above into the joists and beams of the building

13. The six *mortars* hollowed out of the block itself, and in shape pretty much like a kitchen pot.

14. The feet of the pestles rounded into cylinders, and shod with a great lump of iron.

15. A board behind the pestles, standing on its edge, but inclining a little backwards. There is such another in front, but not represented here. These form a sort of trough, which prevents the seed from being scattered about by the fall of the pestles, and lost

16. The first *press-box* (also hollowed out of the block), in which the grain is squeezed, after it has come for the first time from below the millstones.

17. The second *press-box*, at the other end of the block, for squeezing the grain after it has passed a second time under the pestles.

18. Frame of timber for supporting the other end of the wallower, in the same manner as at N° 4 fig B.

19. Small cog wheel on the end of the wallower for giving motion to the millstones. It has 28 teeth.

20. Gudgeon of the wallower, bearing on a bell metal socket fixed in the wall.

21. Vessels for receiving the oil from the press-boxes.

22. Joists supporting the block.

Fig. D. Elevation and mechanism of the millstones.

1. *Upright shaft*, carrying the great cog wheel above, and the *runner millstones* below in their frame.

2. Cog-wheel of 76 cogs, driven by N° 19. of fig C.

3. The frame of the *runners*. This will be more distinctly understood in N° 4. fig. H.

4. The innermost runner, or the one nearest the shaft.

5. Outermost ditto, being farther from the shaft.

6. The *inner rake*, which collects the grain under the outer runner.

7. The *outer rake*, which collects the grain under the inner runner. In this manner the grain is always turned over and over, and crushed in every direction. The inner rake lays the grain in a slope, of which fig. O. is a section; the runner flattens it, and the second rake lifts it again, as is marked in fig P; so that every side of a grain is presented to the millstone, and the rest of the *ligger* or *nether millstone* is so swept by them, that not a single grain is left on any part of it. The outer rake is also furnished with a rag of cloth, which rubs against the border or hoop that surrounds the nether millstone, so as to drag out the few grains which might otherwise remain in the corner.

8. The ends of the iron axle which passes through the upright shaft, and through the two runners. Thus they have two motions: 1*mo*, A rotation round their own axis. 2*do*. That by which they are carried round upon the nether millstone on which they roll. The holes in these millstones are made a little widish; and the holes in the ears of the frame, which carry the ends of the iron axis, are made oval up and down. This great freedom of motion is necessary for the runner millstones, because frequently more or less of the grain is below them at a time, and they must therefore be at liberty to get over it without straining, and perhaps breaking, the shaft.

9. The ears of the frame which lead the two extremities of the iron axis. They are mortised into the under side of the bars of the square frame, that is carried round with the shaft.

10. The border or hoop which surrounds the nether millstone.

11. and 12. The nether millstone and masonry which supports it.

Fig. E. Form of the wallower, shewing the disposition of the wipers along its surface

1. Two parts of this shaft, which are nicely rounded, and fortified with iron plates, and which rest upon the bell metal concaves, which are represented in n° 4. of fig. C.

2. The little wheels at each end, for giving motion to the two spatulæ, marked n° 11. fig. C.

3. The wipers for the second press.

4. The wipers for the first press.

5. The wipers for the six pestles.

Fig. F. Represents the surface of the wallower unfolded into a rectangular parallelogram, in order to shew the distribution of the wipers, and consequently the succession of the strokes given by the different pestles. This distribution has something peculiar Each pestle has three wipers; and there are also three for the driver and discharger of the second press. The driver and wiper of the first press have but one and a half; one for the driver, and the half for the discharger; so that it strikes twice, and the driver only once, in a turn of the shaft. This is the Dutch practice, which differs from that of Flanders. The succession of the strokes may be conceived as follows: Reckon the stampers, including those of the presses, from the water wheel toward the other end of the wallower, and calling them *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, and supposing that *a* makes the first stroke, they proceed in the following order for one turn of the wallower:

ab, *d*, *f*, *h*, *c*, *e*, *g*, *ab*, *d*, *f*, *h*, *c*, *e*, *g*, *ab*, *d*, *f*, *i*, *k*, *c*, *e*, *g*.

Here it may be observed that *a* and *b* strike together. They would do so if allowed; but one of them is held up by its detent till the workman sees proper to disengage it. Each pestle, and the driver and discharger of the second press, makes three strokes for one turn of the wallower. But the driver *k* of the first press makes only one stroke in that time, namely, in the interval between the last strokes of *e* and *g*. The discharger *i* of this press makes two strokes; one of them in this same interval, and the other along with the first stroke of *c*. The second pressing requires a much more violent pressure than the first, because the cake must be left perfectly dry and hard.

Fig. G. Profile of the frame of timber which carries the wallower, and greatly contributes to render its motion steady.

Fig. H. Is a view of one of the millstones.

1. The nether millstones, and the masonry supporting the whole.

2. The runner.

3. A

3. A fort of cafe which enclofes the two wings of the millftone at a very fmall diftance from it, in order to prevent the grain which fticks to it from being fcattered. There is another method practifed at fome mills.

Fig. I. Reprefents that of Sardamm. AA are two iron rods, about half an inch fquare, hanging on the axle, on each fide of the millftone. Thefe rods are joined by a crofs piece C, which almoft touches the millftone. A piece of leather is put between, which rubs upon the millftone, and clears it of the grain which chances to ftick to it. N° 4. and 6. reprefent the ears of this frame, by which the end of the iron axle is fupported, and carried round by the upright fhaft n° 5.

Fig. K. Plan of the runner millftones, and the frame which carries them round.

1, 1. Are the two millftones.

3, 3, 3, 3 The outfide pieces of the frame.

4, 4, 4, 4. The crofs bars of the frame which embrace the upright fhaft 5, and give motion to the whole.

6, 6. The iron axis upon which the runners turn.

7. The outer rake.

8. The inner ditto.

Fig. L. Reprefents the nether millftone feen from above.

1. The wooden gutter, which furrounds the nether millftone.

2. The border or hoop, about fix inches high, all round, to prevent any feed from being fcattered

3. An opening or trap door in the gutter, which can be opened or fhut at pleafure. When open, it allows the bruifed grain, collected in and fhoved along the gutter by the rakes, to pafs through into troughs placed below to receive it.

4. Portion of the circle defcribed by the outer runner.

5. Portion of the circle defcribed by the inner one. By thefe we fee that the two ftones have different routes round the axis, and bruife more feed.

6. The outer rake.

7. The inner ditto.

8. The fweep, making part of the inner rake, occafionally let down for fweeping off all the feed when it has been fufficiently bruifed. The preffure and action of thefe rakes is adjufted by means of wooden fprings, which cannot be eafily and diftinctly reprefented by any figure. The oblique pofition of the rakes (the outer point going foremoft) caufes them to fhove the grain inwards or toward the centre, and at the fame time to turn it over, fomewhat in the fame manner as the mould-board of a plough fhoves the earth to the right hand, and partly turns it over. Some mills have but one fweeper; and, indeed, there is great variety in the form and conftruction of this part of the machinery.

Fig. M. Profile of the peftle frame.

1. Section of the horizontal fhaft

2. Three wipers for lifting the peftles.

3. Little wheel of 28 teeth for giving motion to the fpatula.

4. Another wheel, which is driven by it, having 20 teeth.

5. Horizontal axle of ditto.

6. Another wheel on the fame axle, having 13 teeth.

7. A wheel upon the upper end of the fpindle, having 12 teeth.

8. Two guides, in which the fpindle turns freely, and fo that it can be fhifted higher and lower.

9. A lever, moveable round the piece n° 14. and having a hole in it at 9, through which the fpindle paffes, turning freely. The fpindle has in this place a fhoulder, which refts on the border of the hole 9; fo that by the motion of this lever the fpindle may be difengaged from the wheel work at pleafure. This motion is given to it by means of the lever 10, 10, moveable round its middle. The workman employed at the chauffer pulls at the rope 10, 11, and thus difengages the fpindle and fpatula.

11. A peftle feen fidewife.

12. The *lift* of ditto.

13. The upper rails, marked n° 3. in fig. C.

14. The rail, marked n° 5. in fig. C. To this are fixed the detents, which ferve to ftop and hold up the peftles.

15. A detent, which is moved by the rope at its outer end.

16. A bracket behind the peftles, having a pulley, through which paffes the rope going to the detent 15.

17. The faid pulley.

18. The rope at the workman's hand, paffing through the pulley 17, and fixed to the end of the detent 15.

This detent naturally hangs perpendicular by its own weight. When the workman wants to ftop a peftle, he pulls at the rope 18, during the rife of the peftle. When this is at its greateft height, the detent is horizontal, and prevents the peftle from falling by means of a pin projecting from the fide of the peftle, which refts upon the detent, the detent itfelf being held in that pofition by hitching the loop of the rope upon a pin at the workman's hand.

19. The two lower rails, marked n° 10. fig. C.

20. *Great* wooden, and fometimes ftone, *block*, in which the mortars are formed, marked n° 21. in fig. C.

21. Veffel placed below the prefs boxes for receiving the oil.

22. Chauffer, or little furnace, for warming the bruifed grain.

23. Backet in the front of the chauffer, tapering downwards, and opening below in a narrow flit. The hair bags in which the grain is to be preffed after it has been warmed in the chauffer, are filled by placing them in this backet. The grain is lifted out of the chauffer with a ladle, and put into thefe bags; and a good quantity of oil runs from it through the flit at the bottom into a veffel fet to receive it.

24. The fpatula attached to the lower end of the fpindle, and turning round among the grain in the chauffer-pan, and thus preventing it from fticking to the bottom or fides, and getting too much heat.

Fig. N. Plan of part of the works.

1, 1. Furnaces for warming the grain.

2, 2. The backets for holding the facks while they are a-filling.

3, 3. The pan in which the bruifed grain is heated by the chauffer.

4, 4. A trough for receiving the chips, into which the preffed oil cakes are cut, to be afterwards put into the pan and warmed.

5. The prefs-box for the fecond preffing.

6. The prefs-box for the firft preffing.

7. The fix mortars.

8. The floping boards, to hinder the fcattering of the oil feed.

9. The

9. The nether milſtone, but out of its place.

10. Its centre a little higher than the reſt.

11. A rib of wood going round the edge of the nether milſtone, and even with its ſurface, but riſing a very little outwards, and ſurrounded with a border or hoop about an inch high, to prevent the ſeed from being ſcattered on the ground.

Fig. Q. A ſection, lengthwiſe, of the great block, with the mortars and preſs-boxes.

1. The ſix peſtles.

2. The ſix mortars, each of which has an iron plate at its bottom.

3. The *driving* ſtamper, which falls on the wedge of the firſt preſſing.

4. Ditto, for the ſecond ditto.

5. The *diſcharger*, which ſtrikes on the inverted wedge in order to free the preſs.

6. Ditto, for the ſecond preſſing.

7. Wedge for freeing the preſs.

8. Wedge for preſſing.

9. Wooden *cheeks*, two inches thick, which are placed between the middle wedge and the *ſliding wedges* on each ſide.

10. Preſs-irons, between which are placed the hair-bags containing the bruiſed grain.

11. Iron plate, called the *fountain*, at the bottom, pierced with holes, correſponding with a hole in the block, for allowing the oil to run off from the preſſed grain.

12. Veſſel for receiving ditto.

13. A long iron plate at the bottom of the preſs box, under the drawing and diſcharging wedges.

Fig. R. Another view of the preſs-irons.

1. The ſide-irons laid flat.

2. The ſame ſeen edgewiſe.

3. The pierced iron plate, upon which the two irons, n° 1. ſtand upright, with the hair-bag between them.

4. One of the hair-bags. It may be obſerved that the ſeams of theſe bags are made on the flat ſides, and not on the edges, where they would be in danger of burſting.

5. A long hair-cloth, in which the bag is wrapped before it is ſet into the preſs. The bag, being filled with bruiſed grain, is placed with its bottom at *a*, and the top at *b*; the part *c a* is lapped over it, reaching to *b*, and then the other end *d* is lapped over that, and reaches to *a*, and the loop at its end ſerves as a handle by which to lift it, and place it properly between the preſs-irons.

Fig. S. The principal pieces of the preſs.

1. The wooden cheeks.

2. The diſcharging wedge.

3. The driving wedge.

4 and 5. The ſliding blocks, which tranſmit the preſſure produced by the driving wedge.

The foregoing enumeration and views of the different parts of a Dutch oil-mill, are ſufficient, we imagine, to enable an intelligent mill-wright, to whom the machine is altogether new, to underſtand its manner of working, and its adaptation to the various parts of the proceſs for extracting the oil from ſeeds or kernels. It would require a very minute deſcription indeed to explain it to a perſon altogether unacquainted with mill-work.

The firſt part of the proceſs is bruiſing the ſeed under the runner ſtones (A). That this may be more expeditiouſly done, one of the runners is ſet about ⅔ds of its own thickneſs nearer the ſhaft than the other. Thus they have different treads; and the grain, which is a little heaped towards the centre, is thus bruiſed by both. The inner rake gathers it up under the outer ſtone into a ridge, of which the ſection is repreſented in Plate XL. fig. O. The ſtone paſſes over it and flattens it. It is gathered up again into a ridge, of the form of fig. P. under the inner ſtone, by the outer rake, which conſiſts of two parts. The outer part preſſes cloſe on the wooden border which ſurrounds the nether ſtone, and ſhoves the ſeed obliquely inwards, while the inner part of this rake gathers up what had ſpread toward the centre. The other rake has a joint near the middle of its length, by which the outer half of it can be raiſed from the nether ſtone, while the inner half continues preſſing on it, and thus ſcrapes off the moiſt paſte. When the ſeed is ſufficiently bruiſed, the miller lets down the outer end of the rake. This immediately gathers the whole paſte, and ſhoves it obliquely outwards to the wooden rim, where it is at laſt brought to a part that is left unboarded, and it falls through into troughs placed to receive it. Theſe troughs have holes in the bottom, through which the oil drips all the time of the operation. This part of the oil is directed into a particular ciſtern, being conſidered as the pureſt of the whole, having been obtained, without preſſure, by the mere breaking of the hull of the ſeed.

In ſome mills this operation is expedited, and a much greater quantity of this beſt oil is obtained, by having the bed of maſonry which ſupports the legger formed into a little furnace, and gently heated. But the utmoſt care is neceſſary to prevent the heat from becoming conſiderable. This, enabling the oil to diſſolve more of the fermentable ſubſtance of the ſeed, expoſes the oil to the riſk of growing ſoon very rancid; and, in general, it is thought a hazardous practice, and the oil does not bring ſo high a price.

When the paſte comes from under the ſtones, it is put into the hair bags, and ſubjected to the firſt preſſing. The oil thus obtained is alſo eſteemed as of the firſt quality, ſcarcely inferior to the former, and is kept apart (The great oil ciſtern being divided into ſeveral portions by partitions).

The oil cakes of this preſſing are taken out of the bags, broken to pieces, and put into the mortars for the firſt *ſtamping*. Here the paſte is again broken down, and the parenchyma of the ſeed reduced to a fine meal. Thus free egreſs is allowed to the oil from every veſicle in which it was contained. But it is now rendered much more clammy, by the forcible mixture of the mucilage,

(A) We are told, that in a mill at Reichenhoffen in Alſace, a conſiderable improvement has been made by paſſing the ſeed between two ſmall iron rollers, before it is put under the milſtones. A great deal of work is ſaid to be ſaved by this preliminary operation, and finer oil produced, which we think very probable. The ſtamping and preſſing go on as in other mills.

ciiage, and even of the finer parts of the meal. When sufficiently pounded, the workman stops the pestle of a mortar, when at the top of its lift, and carries the contents of the mortar to the first chauffer pan, where it is heated to about the temperature of melting bees wax (this, we are told, is the test), and all the while stirred about by the spatula. From thence it is again put into hair bags, in the manner already described; and the oil which drips from it during this operation is considered as the best of the second quality, and in some mills is kept apart. The paste is now subjected to the second pressing, and the oil is that of the second quality.

All this operation of pounding and heating is performed by one workman, who has constant employment by taking the four mortars in succession. The putting into the bags and conducting of the pressing gives equal employment to another workman.

In the mills of Piccardy, Alsace, and most of Flanders, the operation ends here; and the produce from the chauffer is increased, by putting a spoonful or two of water into the pan among the paste.

But the Dutch take more pains. They add no water to the paste of this their *first stamping*. They say that this greatly lowers the quality of the oil. The cakes which result from this pressing, and are there sold as food for cattle, are still fat and softish. The Dutch break them down, and subject them to the pestles for the *second stamping*. These reduce them to an impalpable paste, stiff like clay. It is lifted out, and put into the *second* chauffer pan, a few spoonfuls of water are added, and the whole kept for some time as hot as boiling water, and carefully stirred all the while. From thence it is lifted into the hare bags of the last press, subjected to the press; and a quantity of oil, of the lowest quality, is obtained, sufficient for giving a satisfactory profit to the miller. The cake is now perfectly dry, and hard, like a piece of board, and is sold to the farmers. Nay, there are small mills in Holland, which have no other employment than extracting the oil from the cakes which they purchase from the French and Brabanters; a clear indication of the superiority of the Dutch practice.

The nicety with which that industrious people conduct all their business is remarkable in this manufacture.

In their oil cistern the parenchymous part, which unavoidably gets through, in some degree, in every operation, gradually subsides, and the liquor, in any division of the cistern, comes to consist of strata of different degrees of purity. The pumps which lift it out of each division are in pairs; one takes it up from the very bottom, and the other only from half depth. The last only is barrelled up for the market, and the other goes into a deep and narrow cistern, where the dreg again subsides, and more pure oil of that quality is obtained. By such careful and judicious practices, the Dutch not only supply themselves with this important article, but annually send considerable quantities into the very provinces of France and Flanders where they bought the seed from which it was extracted. When we reflect on the high price of labour in Holland, on the want of timber for machinery, on the expence of building in that country, and on the enormous expence of wind mill machinery, both in the first erection and the subsequent wear and tear, it must be evident, that oil mills erected in England on water falls, and after the Dutch manner, cannot fail of being a great national advantage. The chatellanie or seigneurie of Lille alone makes annually between 30,000 and 40,000 barrels, each containing about 26 gallons.

What is here delivered is only a sketch. Every person acquainted with machinery will understand the general movements and operations. But the intelligent mechanic well knows, that operations of this kind have many minute circumstances which cannot be described, and which, nevertheless, may have a great influence on the whole. The rakes in the bruising-mill have an office to perform which resembles that of the hand, directed by a careful eye and unceasing attention. Words cannot communicate a clear notion of this; and a mill, constructed from the best drawings, by the most skilful workman, may gather the seed so ill, that the half of it shall not be bruised after many rounds of the machinery. This produces a scanty return of the finest oil; and the mill gets a bad character. The proprietor loses his money, is discouraged, and gives up the work.—There is no security but by procuring a Dutch millwright, and paying him with the liberality of Britons. Such unhoped-for tasks have been performed of late years by machinery; and mechanical knowledge and *invention* is now so generally diffused, that it is highly probable that we should soon excel our teachers in this branch But this very diffusion of knowledge, by encouraging speculation among the artists, makes it a still greater risk to erect a Dutch oil-mill without having a Dutchman, acquainted with its most improved present form, to conduct the work. We do our duty in giving this counsel.

OKU-JESSO. See SEGALIEN in this *Suppl.*

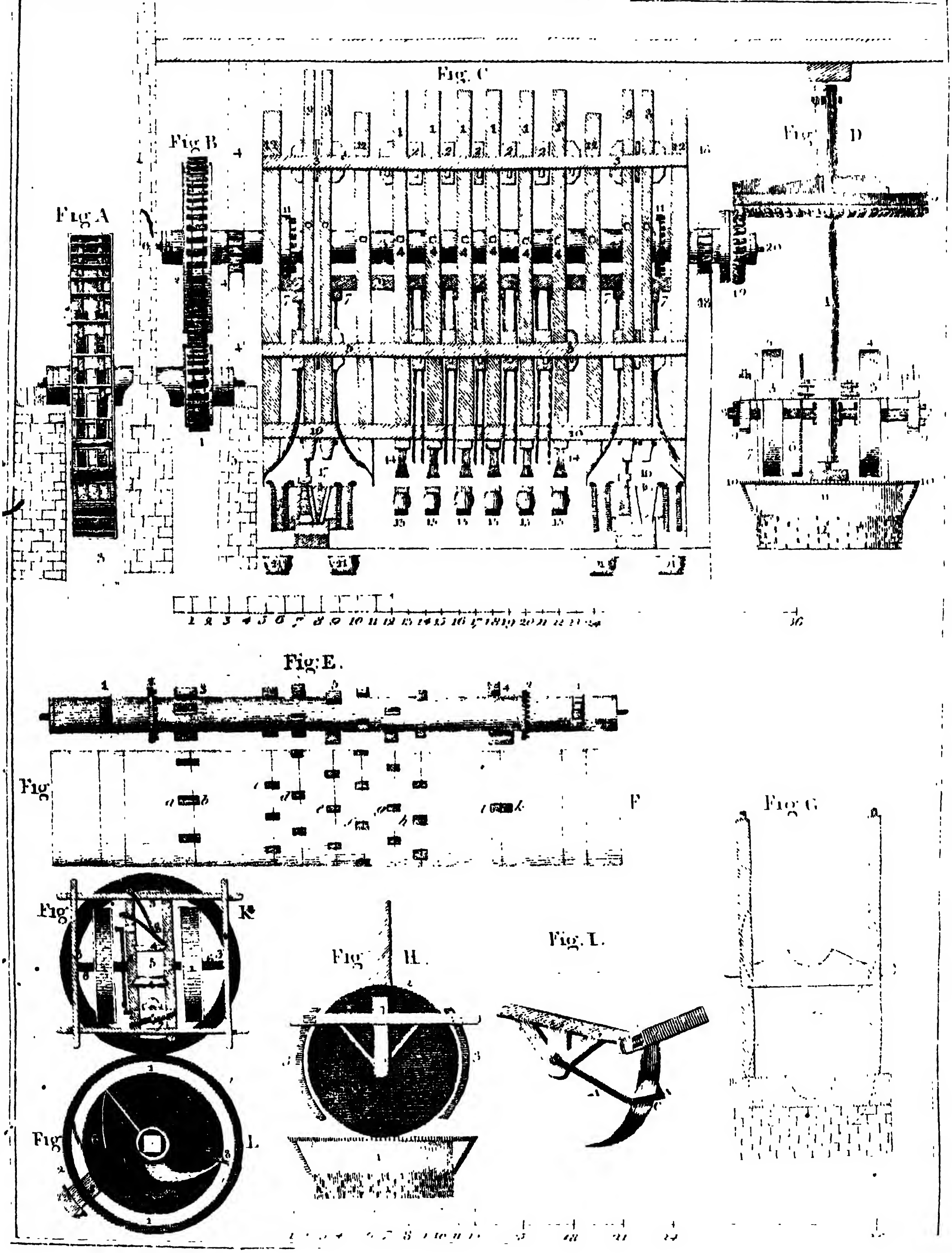
OMPHALOPTER, or OMPHALOPTIC, in optics, a glass that is convex on both sides, popularly called a *convex lens*.

ONISCUS (See *Encycl.*). Two new species of this genus of insects were discovered by *La Martiniere*, the naturalist who accompanied Perouse on his last voyage of discovery. For the information of such of our readers as are entomologists, we shall give the author's description of these species. Of the first, which he says only *nearly* answers to the *generic* character of oniscus, E (fig. 1.) is a view of the upper part of its body, and at F of the lower. Its body is crustaceous, and of an opaque white, with two round rust-coloured spots on the anterior part of its corslet; two others, much larger, in the form of a crescent, are on the *elytræ*; its shield is also of the same colour. The under part of the thorax is furnished with four pair of legs; the first and third of which are terminated with sharp claws; the second, from its form, serves it to swim with; the fourth is very small, consisting of two membranaceous threads. Some scales, also membranaceous and very channelled, may also perform the office of legs; of these the two lower are the largest. Its belly is filled with vermicular intestines of the size of a hair; its mouth is placed between the first and second pair of legs, and is of the form of a small trunk placed between two lips, joined only at the upper extremity.

Plate XXXII.

Fig. 2. represents an insect of the genus *oniscus Linn.* Its body is nearly of the form, consistence, and colour, of the *oniscus asellus*, except that it is not divided

OIL MILL PLATE XXXVIII



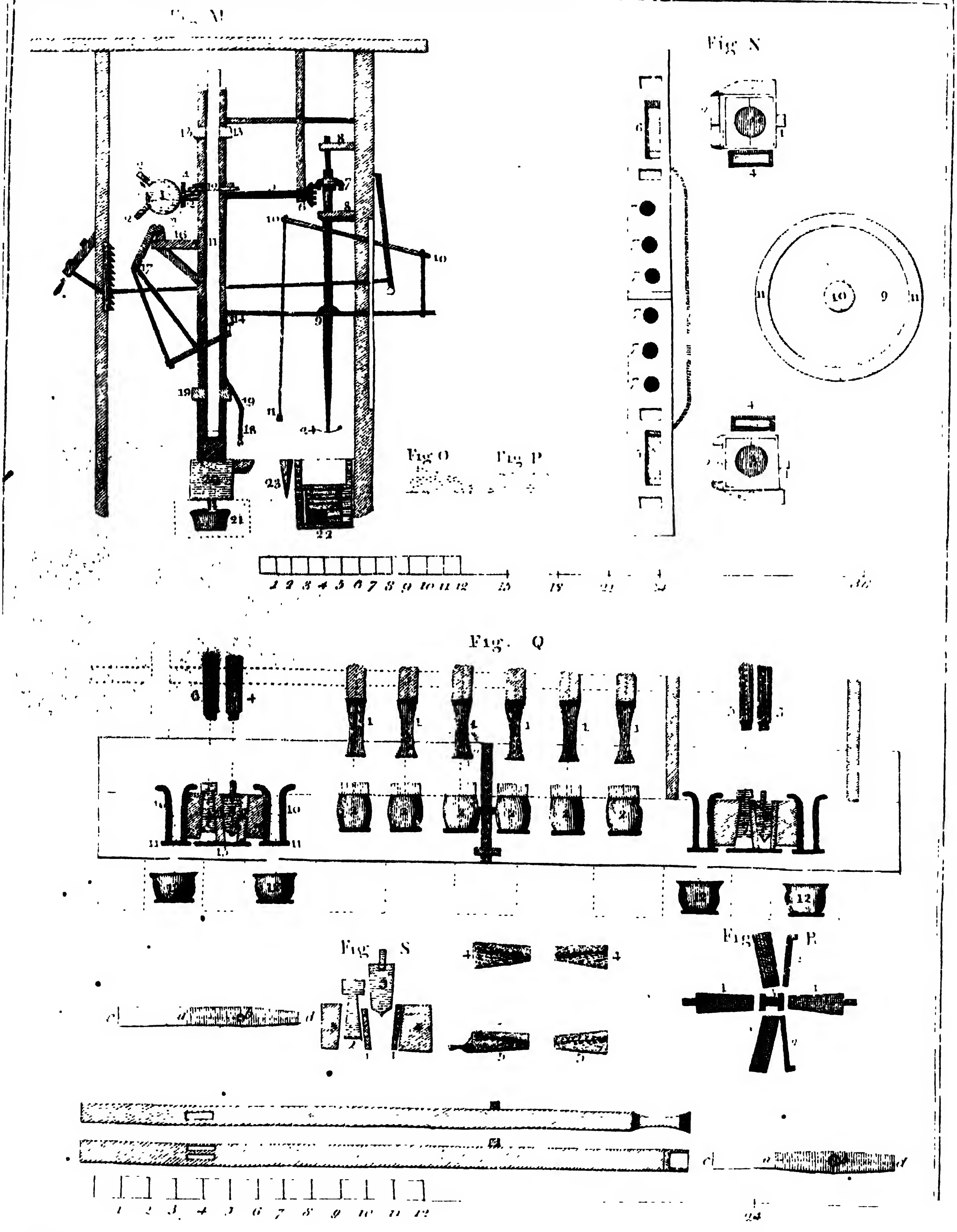


Fig. N
Fig. O
Fig. P
Fig. Q
Fig. S
Fig. R

vided by ſegments as this laſt is. It has a double tail three times as long as the body; from the inſertion of which, at the hinder part of the body, ſpring two legs, uſed chiefly by the animal in ſwimming upon its back. The inſect, viewed on the lower part H, preſents ſix pair of legs: the two firſt of which terminate in very ſharp and thick points; it makes uſe of the third to ſwim with, and to balance its body, together with that pair which is inſerted at the baſe of the tail; the fourth pair, and the largeſt of all, is armed with two very ſharp points, which the animal forces into the body of any fiſh on which it ſeizes; the two laſt pair are nothing more than very finely divided membranes. Between the two firſt is ſituated its trunk, ſmooth, and about half a line long; at the baſe of the third pair are two points, of a horny conſiſtence, very hard, and firmly fixed. The two horns alſo below the large pair of legs are, in like manner, very firmly united to its body. Martiniere imagines it to be by means of theſe darts that it pierces the body of the fiſh on which it is found, and that then, changing its ſituation, it finds means to introduce its trunk into the holes thus formed. When put into a glaſs it ſinks to the bottom, and riſes again to the ſurface with the greateſt eaſe, advancing with the edge of its body, and deſcribing curves. Its two long tails are very eaſily pulled off, without the animal appearing to ſuffer any pain.

OPAQUE, not tranſlucent, nor tranſparent, or not admitting a free paſſage to the rays of light.

OPARO or Oparro, the name given by Captain Vancouver to a ſmall iſland which he diſcovered in latitude 27° 36′ ſouth, and in longitude 215° 49′ eaſt from Greenwich. It was eſtimated at about 6½ miles in length, and no other land was in ſight. Its principal character is a cluſter of high craggy mountains, forming, in ſeveral places, moſt romantic pinnacles, with perpendicular cliffs nearly from their ſummits to the ſea: the vacancies between the mountains would more properly be termed chaſms than valleys. The tops of ſix of the higheſt hills bore the appearance of fortified places, reſembling redoubts; having a ſort of blockhouſe, in the ſhape of an Engliſh glaſs-houſe, in the centre of each, with rows of palliſadoes a conſiderable way down the ſides of the hills, nearly at equal diſtances. Theſe overhanging, ſeemed intended for advanced works, and apparently capable of defending the citadel by a few againſt a numerous hoſt of aſſailants. On all of them people were noticed as if on duty, conſtantly moving about. What we conſidered (ſays the author) as block-houſes, from their great ſimilarity in appearance to that ſort of building, were ſufficiently large to lodge a conſiderable number of perſons, and were the only habitations we ſaw. Yet, from the number of canoes that in ſo ſhort a time aſſembled round the Engliſh ſhip, it is natural to conclude, that the inhabitants are very frequently afloat; and to infer, that the ſhores, and not thoſe fortified hills which appeared to be in the centre of the iſland, would be preferred for their general reſidence.

Whether the fortified places here deſcribed were intended for defences of the iſlanders againſt each other, or againſt attacks from ſome more powerful neighbours, could only be conjectured; but the latter idea ſeems the moſt probable. From the language of the people, and their reſemblance to the Friendly iſlanders, Captain Vancouver conſiders them all as having ſprung from the ſame original ſtock. The people of Oparo, however, are diſtinguiſhed by two circumſtances, certainly in their favour. Not one of them was tattowed; and though they appeared not to have ever ſeen a European before, they all ſeemed perfectly well acquainted with the uſes to which they could apply iron, and preferred articles of it to looking glaſſes, beads, and other trinkets, with which ſavages are uſually delighted. Though there appeared to be anchoring ground near the north weſt end of the iſland, circumſtances rendered it inconvenient for Captain Vancouver to land on it, ſo that we are yet in a great meaſure ſtrangers to the diſpoſitions of the people, though they appeared to be hoſpitable.

OPEN Flank, in fortification, is that part of the flank which is covered by the orillon or ſhoulder.

OPENING *of the Trenches*, is the firſt breaking of ground by the beſiegers, in order to carry on their approaches towards a place.

OPERA Glass, is a diagonal perſpective, of which the following conciſe and perſpicuous deſcription is taken from Dr Hutton's Mathematical Dictionary.— ABCD (Plate XLI) repreſents a tube about four inches long; in each ſide of which there is a hole EF and GH, exactly againſt the middle of a plane mirror IK, which reflects the rays falling upon it to the convex glaſs LM; through which they are refracted to the concave eye-glaſs NO, whence they emerge parallel to the eye at the hole *r s*, in the end of the tube. Let P *a* Q be an object to be viewed, from which proceed the rays P *c*, *a b*, and Q *d*: theſe rays, being reflected by the plane mirror IK, will ſhew the object in the direction *c p*, *b a*, *d q*, in the image *p q*, equal to the object PQ, and as far behind the mirror as the object is before it: the mirror being placed ſo as to make an angle of 45 degrees with the ſides of the tube. And as, in viewing near objects, it is not neceſſary to magnify them, the focal diſtances of both the glaſſes may be nearly equal; or, if that of LM be three inches, and that of NO one inch, the diſtance between them will be but two inches, and the object will be magnified three times, being ſufficient for the purpoſes to which this glaſs is applied.

When the object is very near, as XY, it is viewed through a hole *x y*, at the other end of the tube AB, without an eye-glaſs; the upper part of the mirror being poliſhed for that purpoſe as well as the under. The tube unſcrews near the object-glaſs LM, for taking out and cleanſing the glaſſes and mirror. The poſition of the object will be erect through the concave eye-glaſs.

The peculiar artifice of this glaſs is to view a perſon at a ſmall diſtance, ſo that no one ſhall know who is obſerved; for the inſtrument points to a different object from that which is viewed; and as there is a hole on each ſide, it is impoſſible to know on which hand the object is ſituated which you are viewing. It is chiefly uſed in play houſes; and hence its name: but we have ſeen it moſt indecently employed by thoſe who ſhould have ſet a better example, even in a cathedral church!

OPHRYS (See *Encycl.*). A new ſpecies of this plant has been lately deſcribed in the *Annual Hampſhire Repoſitory*, by a Fellow of the Linnean Society in the following words:

" *Stem*—about 12 inches high, erect, [illegible]

culate,

culate, pubescent at the upper genicles. *Spike*—strictly spiral, flowers spirally ascending, about 24, brightly white. Upper petal ovato acuminate, pubescent, lightly ciliate, straight. Two middle *petals* oblong-recurved. Two lower *petals* oblong acuminate, lightly ciliate only on the lower side near the base, projecting like elephant's tusks. *Nectary*, broad, recurved, ragged, bicipitate. *Leaves floral*—carinate acuminate, ciliate reaching and pointing to the middle of the flowers. *Leaves radical*—five or six, about six inches long, narrow, attenuate both ways, acuminate, the lower more hastate. *Leaves cauline*—lanceolate, alternate.

"Observation.—This plant has much the habit, as well as autumnal florescence, of Oriental spiralis, and is so perfectly spiral also, that the specific name of the other should be altered, as being no longer exclusively spiral; at the same time that a specific name should be given to this: neither of which (says the author) I shall presume to do, but shall suggest it to the Linnean Society, of which I have the honour to be a Fellow."—This ophrys flowered, for the first time, it is believed, in England, in Hampshire, October 1796.

OPHIUCUS, a constellation of the northern hemisphere; called also *Serpentarius*.

OPIUM (See *Encycl.*), is a medicine of such intrinsic value, and of so high a price, that every method which promises to increase the quantity in the market must be of importance. It was therefore, with much propriety, that *the Society for the Encouragement of Arts, &c.* some time ago, voted 50 guineas to Mr John Ball of Williton, Somersetshire, for the discovery of his method of preparing opium from poppies of the growth of England. The poppies, which he recommends as the most productive, are the *double* or *semi-double*, of a dark colour; the seeds of which he advises to be sown the latter end of February, and again about the second week in March, in beds three feet and a half wide (well prepared with good rotten dung, and often turned or ploughed, in order to mix it well, and have it fine), either in small drills, three in each bed, in the manner sallads are sown, and when about two inches high, to thin them one foot apart; or otherwise, to sow them in beds, in the broad-cast way, and thin them to the same distance. If they be kept free from weeds, they will grow well, and will produce from four to ten heads, shewing large and different coloured flowers; and when their leaves die away, and drop off, the pods then being in a green state, is the proper time for extracting the opium, by making such longitudinal incisions as are, for this purpose, made in the east (See OPIUM and PAPAVER, *Encycl.*). Immediately on the incision being made, a milky fluid will issue out; which is the opium, and which, being of a glutinous nature, will adhere to the bottom of the incision; but some poppies are so productive, that it will drop from the pod on the leaves underneath. The next day, if the weather should be fine, and a good deal of sunshine, the opium will be found a greyish substance, and some almost turning black: it is then to be scraped from the pods, and (if any there) from the leaves, with the edge of a knife, or other instrument for that purpose, into pans or pots; and in a day or two it will be of a proper consistence to make into a mass, and to be potted.

According to Mr Ball, fields cannot be sown with any thing more lucrative to the farmer than poppies, especially if those fields have a south exposure. "By a calculation (says he) which I have made, supposing one poppy to grow in one square foot of earth, and to produce only one grain of opium, more than L. 50 will be collected from one statute acre of land; but if we consider, that one poppy produces from three or four to ten heads, that in each head from six to ten incisions may be made, and that from many of them (I mean from one incision) I have taken away two or three grains of opium—What must then be the produce?"

Mr Ball produced to the Society letters from Dr Latham of Bedford-row, Dr Pearson of Leicester-square, and Mr Wilson of Bedford-street, declaring, that, in their opinion, his English opium is equal in effect, and superior in purity, to the best foreign opium.

OPTIC INEQUALITY, in astronomy, is an apparent irregularity in the motions of far distant bodies; so called, because it is not really in the moving bodies, but arising from the situation of the observer's eye. For if the eye were in the centre, it would always see the motions as they really are.

OPTIC *Pyramid*, in perspective, is a pyramid formed by the visible object which is the *base*, and the rays drawn from the perimeter of that object, which meet at the eye in a point, which is the *apex* of the pyramid. Hence, also, we may know what is meant by an *optic triangle*.

OPTIC *Rays*, particularly means those by which an optic pyramid, or optic triangle, is terminated.

ORAN, a considerable city, occupied by the Spaniards, in the province of *Mascara*, in the country of Algiers. It has strong and regular fortifications, and can easily be supplied from Spain with provisions and warlike stores. It lies in 35′ of longitude west from Greenwich, and in 35° 55′ north latitude. Since the year 1732, the Spaniards have held uninterrupted possession of Oran. It has a parish-church, three monasteries, an hospital: and the number of the inhabitants, according to the account given of it by the Spaniards, amount to 12,000. Towards the sea, the city rises in the form of an amphitheatre, and is surrounded with forts and batteries. Close to the city lies a strong castle, *Alcazava*, in which the Spanish governor resides. On the highest hill stands Fort St Croix, whose guns command the city and the adjacent country. From this fort they make signals of the approach of ships, and carefully watch the motions of the Moors, who often attempt predatory incursions into the neighbouring districts. A considerable number of Mahomedans take refuge in Oran; they dwell in a distinct part of the city, receive pay from the court of Spain, and render signal services against the Moors. The greatest part of the inhabitants of Oran consists of such as have been banished from Spain; and the same may, in a great measure, be said of the soldiers who compose the garrison. Five regiments are commonly stationed here; but, owing to continual desertion, their strength scarcely equals that of four complete regiments. One of them wholly consists of malefactors, who have been condemned to remain here for life; the rest are such as have been transported for one or more years. There is here likewise a military school. Around the city are pleasant gardens; but it is very dangerous to cultivate them, on account of the Moors and Arabs, who frequently lie in ambush among them. The same reason prevents the cultivation of the fields in the vicinity; and the garrison

fon and inhabitants muft be fupplied with provifions immediately from Spain.

ORANGE-MEN, an appellation affumed by certain focieties in Ireland, of which the firft was formed in the county of Armagh, on the 21ft of November 1795, others in fome towns of Ulfter and Leinfter in the year 1797, another in the city of Dublin 1798; and fince that period, thefe focieties have fpread over the whole of our fifter kingdom. The object of thefe affociations is exhibited in the following authentic *Declaration of the Principles of Orange-men*, publifhed 1799.

"From the various attempts that have been made to poifon the public mind, and flander thofe who have had the fpirit to adhere to their king and conftitution, and to maintain the laws:—

"We, the Proteftants of Dublin, affuming the name of Orange-men, feel ourfelves called upon, not to vindicate our principles, for we know that our honour and loyalty bid defiance to the fhafts of malevolence and difaffection, but openly to avow thofe principles, and declare to the world the objects of our inftitution.

"We have long obferved, with indignation, the efforts that have been made to foment rebellion in this kingdom, by the feditious, who have formed themfelves into focieties, under the fpecious name of *United Irifh*.

"We have feen with pain the lower orders of our fellow-fubjects, forced or feduced from their allegiance, by the threats or machinations of *traitors*.

"And we have viewed with horror the fuccefsful exertions of *mifcreants*, to encourage a foreign enemy to invade this happy land, in hopes of rifing into confequence on the downfal of their country.

"We therefore thought it high time to rally round the conftitution, and there pledge ourfelves to each other, to maintain the laws, and fupport our good king againft all his enemies, whether *rebels* to their God or to their country; and by fo doing, fhew to the world that there is a body of men in this ifland, who are ready, in the hour of danger, to ftand forward in defence of that grand palladium of our liberties, the conftitution of Great Britain and Ireland, obtained and eftablifhed by the courage and loyalty of our anceftors under the Great King William.

"Fellow-fubjects, we are accufed with being an *inftitution*, founded on principles too fhocking to repeat, and bound together by oaths, at which human nature may fhudder: but we caution you not to be led away by fuch malevolent falfehoods; for we folemnly affure you, in the prefence of the Almighty God, that the idea of injuring any one, on account of his religious opinion, never entered into our *hearts*: we regard every loyal fubject as our friend, be his religion what it may; we have no enmity but to the enemies of our country.

"We farther declare, that we are ready, at all times, to fubmit ourfelves to the orders of thofe in authority under his majefty, and that we will cheerfully undertake any duty which they fhall think proper to point out for us, in cafe either a foreign enemy fhall dare to invade our coafts, or that a domeftic foe fhall prefume to raife the ftandard of rebellion in the land. To thefe principles we are pledged—and in fupport of them we are ready to fpend the laft drop of our blood.—(Signed) Thomas Verner, *Grand Mafter*; John Clau. Beresford, *Grand Secretary*; William James, J. De Joncourt, Edward Ball."

Orchard.

ORCHARD. As an appendix to this article in the *Encycl.* fome of our readers will be pleafed with the following means, employed by the Rev. Mr *Germerfhaufen*, for promoting the growth of young trees, and increafing the fize and flavour of the fruit in orchards.

Having planted feveral young plum trees in an orchard, he covered the ground, for fome years, around the trunks, as far as the roots extended, with flax-fhows (A); by which means thefe trees, though in a grafs-field, increafed in a wonderful manner, and far excelled others planted in cultivated ground. As far as the fhows reached, the grafs and weeds were choaked; and the foil under them was fo tender and foft, that no better mould could have been wifhed for by a florift.

When he obferved this, he covered the ground with the fame fubftance, as far as the roots extended, around an old plum-tree, which appeared to be in a languifhing ftate, and which ftood in a grafs-field. The confequences were, that it acquired a ftrong new bark; produced larger and better-tafted fruit; and that thofe young fhoots, which before grew up around the ftem, and which it was every year neceffary to deftroy, were prevented from fprouting forth, as the covering of flax-fhows impeded the free accefs of air at the bottom of the trunk.

In the year 1793, he tranfplanted, from feed-beds, into the nurfery, feveral fruit-trees; the ground around fome of which he covered, as above, with flax-fhows. Notwithftanding the great heat of the fummer, none of thofe trees where the earth was covered with fhows died or decayed; becaufe the fhows prevented the earth under them from being dried by the fun. Of thofe trees, around which the ground was not covered as before mentioned, the fourth part mifcarried; and thofe that continued alive were far weaker than the former.

The leaves which fall from trees in autumn may alfo be employed for covering the ground in like manner; but ftones, or logs of wood, muft be laid on them, to prevent their being difperfed by the wind. In grafs-land, a fmall trench may be made around the roots of the tree, when planted, in order to receive the leaves. If flax fhows are ufed, this is not neceffary; they lie on the furface of the ground fo faft as to refift the force of the moft violent ftorm. The leaves which our author found moft effectual in promoting the growth and fertility of fruit trees, are thofe of the walnut tree. Whether it is, that, on account of their containing a greater abundance of faline particles, they communicate manure to the ground, which thereby becomes tender under them; or that they attract nitrous particles from the atmofphere; or that, by both thefe means, they tend to nourifh the tree both above and below.

Thofe who are defirous of raifing tender exotic trees from the feed, in order to accuftom them to our climate, may, when they tranfplant them, employ flax-fhows with

(A) Shows are the refufe of flax when it is fcutched or heckled.

with great advantage. This covering will prevent the frost from making its way to the roots; and rats and mice, on account of the sharp prickly points of the flax shows, will not be able to shelter themselves under them.

ORCHILLA, a weed used in dyeing, which grows in the Canary islands, and is monopolized by the government. "It is a minute vegetable (says Sir George Staunton), of the lichen kind, growing chiefly upon rocks of a loose texture, and produces a beautiful violet blue colour."

ORDEAL. See this article in the *Encyclopædia*, at the end of which we have given, from Dr Henry's History of England, some strong reasons for suspecting that the ordeal, by fire at least, was a gross imposition on the credulity of an ignorant and superstitious age. This suspicion of imposture is raised to certainty by Professor Beckmann, who, in his History of Inventions, gives us the whole process by which the clergy conducted the trial, and brought proofs of innocence or of guilt at their pleasure. The person accused was put entirely under their management for three days before the trial, and for as many after it. They covered his hands (when he was to lift red-hot iron) both before and after the proof; sealed and unsealed the covering. The former was done, as they pretended, to prevent the hands from being prepared any how by art; the latter, that it might be accurately known whether or not they were burnt.

Some artificial preparation was therefore known, else no precautions would have been necessary. It is highly probable, that during the three first days the preventative was applied to those persons whom they wished to appear innocent; and that the three days after the trial were requisite to let the hands resume their natural state. The sacred sealing secured them from the examination of presumptuous unbelievers: for to determine whether the hands were burnt, the three last days were certainly not wanted. When the ordeal was abolished, and this art rendered useless, the clergy no longer kept it a secret. In the 13th century, an account of it was published by Albertus Magnus, a Dominican monk (A). If his receipt be genuine, it seems to have consisted rather in covering the hands with a kind of paste than in hardening them. The sap of the *althæa* (marshmallow), the slimy seeds of the flea-bane, which is still used for stiffening by the hat-makers and silk-weavers, together with the white of an egg, were employed to make the paste adhere. And by these means the hands were as safe as if they had been secured by gloves.

ORFFYREUS'S WHEEL, in mechanics, is a machine so called from its inventor, which he asserted to be a perpetual motion. This machine, according to the account given of it by Gravesande, in his *Oeuvres Philosophiques*, published by Allemand, Amst 1774, consisted externally of a large circular wheel, or rather drum, 12 feet in diameter, and 14 inches deep; being very light, as it was formed of an assemblage of deals, having the intervals between them covered with waxed cloth, to conceal the interior parts of it. The two extremities of an iron axis, on which it turned, rested on two supports. On giving a slight impulse to the wheel, in either direction, its motion was gradually accelerated; so that, after two or three revolutions, it acquired so great a velocity as to make 25 or 26 turns in a minute. This rapid motion it actually preserved during the space of two months, in a chamber of the Landgrave of Hesse, the door of which was kept locked, and sealed with the Landgrave's own seal. At the end of that time it was stopped, to prevent the wear of the materials. The Professor, who had been an eye witness to these circumstances, examined all the external parts of it, and was convinced that there could not be any communication between it and any neighbouring room. Orffyreus, however, was so incensed, or pretended to be so, that he broke the machine in pieces, and wrote on the wall, that it was the impertinent curiosity of Professor Gravesande which made him take this step. The Prince of Hesse, who had seen the interior parts of this wheel, but sworn to secrecy, being asked by Gravesande, whether, after it had been in motion for some time, there was any change observable in it, and whether it contained any pieces that indicated fraud or deception? answered both questions in the negative, and declared, that the machine was of a very simple construction.

Hutton's Dictionary.

ORICOU, a new species of the vulture, discovered by Vaillant at Orange river in South Africa. As he thinks it unquestionably the most beautiful of its genus, and tells, as usual with him, a wonderful story about it, we have given a figure of this vulture in Plate XLI. Our traveller says, that it is more than three feet high, and eight or nine in breadth of wing. Its feathers, the general hue of which is a light brown, are of a particular kind on the breast, belly, and sides, where they are of unequal lengths, pointed, curved like the blade of a sabre, and bristle up distinct from each other. The feathers being thus separated, would disclose to view the skin on the breast, if it were not completely covered with a very thick and beautiful white down, which is easily seen between the ruffled plumage.

A celebrated naturalist has said, that "no bird has eye lashes or eye-brows, or, at least, hair round the eyes like that in quadrupeds." This assertion, advanced as a general law of Nature, is a mistake. Not only the oricou has this peculiarity, but we know of many other species in which it exists; such as, in general, all the calaos, the secretary, and several other birds of prey. Beside these eye lashes, the vulture in question has stiff black hairs on its throat. All the head and part of the neck are bare of feathers; and the naked skin, which is of a reddish colour, is dashed in certain places with blue, violet, and white. The ear, in its external circumference, is bounded by a prominent skin, which forms a sort

(A) In his work *De Mirabilibus Mundi*, at the end of his book *De Secretis Mulierum*, Amstelod. 1702, 12mo, p. 105. Experimentum mirabile quod facit hominem ire in ignem sine læsione, vel portare ignem vel ferrum ignitum sine læsione in manu. Recipe succum bismalvæ. et albumen ovi, et semen psylli et calcem, et pulveriza, et confice cum illo albumine ovi succum raphani; commisce; ex hac confectione illineas corpus tuum vel manum, et dimitte siccari, et postea iterum illineas, et post hoc poteris audacter sustinere ignem sine nocu-

fort of rounded conch, that muft neceffarily heighten the faculty of hearing in this fpecies. This kind of conch is prolonged for fome inches, and defcends down the neck; which induced our author to give it the name of *oricou*.

Its ftrength, he fays, muft be very confiderable, if we may judge from its mufcles and finews; and he is perfuaded, that there is not a ftronger among the whole order of carnivorous birds, not excepting the famous condor, which fo many travellers have feen, but of which their defcriptions are fo different as to render its exiftence extremely doubtful. But there was no occafion for this reafoning, and thofe inferences, if what he relates as facts deferve any credit. The oricou which he defcribes, he firft perceived perched on the carcafe of a hippopotamos, eagerly devouring its flefh. He fhot at it, and wounded it flightly; upon which, "though it had already gorged itfelf with a confiderable quantity of flefh (for upon opening it, he found in its ftomach no lefs a quantity than *fix pounds and a half*), yet its hunger and voracity were fuch, that it ftruck its beak into the carcafe when attempting to take wing, as if defirous of carrying the whole of it away.

"On the other hand, the weight of the flefh it had devoured rendering it the more heavy, it could not eafily rife; fo that we had time (fays he) to reach it before it was on the wing, and we endeavoured to knock it on the head with the but-ends of our mufkets. It defended itfelf a long time with great intrepidity. It bit or ftruck at our weapons with its beak, and its ftrength was ftill fo great, that every ftroke made a mark on the *barrel of the piece*."

ORIENT, the eaft, or the eaftern point of the horizon.

ORIENT *Equinoctial*, is ufed for that point of the horizon where the fun rifes when he is in the equinoctial, or when he enters the figns Aries and Libra.

ORIENT *Aeftival*, is the point where the fun rifes in the middle of fummer, when the days are longeft.

ORIENT *Hybernal*, is the point where the fun rifes in the middle of winter, when the days are fhorteft.

OROTAVA, a town in the ifland of Teneriffe, at the bottom of thofe mountains out of which the Peek rifes, neatly built of ftone, on an irregular furface. The moft remarkable object near it is a dragon's blood tree, of which the trunk meafures, at the height of ten feet from the ground, 36 feet in girth. Concerning this tree there is a tradition current in the ifland, that it exifted, of no inconfiderable dimenfions, when the Spaniards made the conqueft of Teneriffe, about three centuries ago; and that it was then, what it ftill is, a landmark, to diftinguifh the boundaries of landed poffeffions near it.

Diftant about three miles on the fea coaft is the puerto, or fea-port, of Orotava, where is carried on a confiderable degree of commerce, principally for the exportation of wine. It is chiefly, as at Madeira, in the hands of a few Britifh commercial houfes, which import, in return, the manufactures of Great Britain. Within a mile is a collection of living plants from Mexico, and other parts of the Spanifh dominions in America. From hence they are to be tranfplanted into Spain. It is an eftablifhment of fome expence; and, whatever may be its fuccefs, it fhews a laudable attention, on the part of that government, to the promotion of natural knowledge.

Orotchys.

OROTCHYS and BITCHYS, two tribes of Tartars, who were vifited by La Peroufe in 1787, and of whofe manners he gives fuch an account as renders it difficult to fay whether they have the beft claim to be called a favage or a civilized people. He fell in with a fmall village of them on the eaft coaft of Tartary, in a bay to which he gave the name of *Baie de Caftrie*, in Lat. 51° 29′ North, and Lon. 139° 39′ Eaft from Paris.

Their village, their employment, their drefs, and their apparent ignorance of all religion, befpoke them favages. Their village was compofed of four cabins, built in a folid manner, of the trunks of fir-trees, and covered with bark. A wooden bench compaffed the apartment round about; and the hearth was placed in the middle, under an opening large enough to give vent to the fmoke.

This village was built upon a tongue of low marfhy land, which appeared to be uninhabitable during the winter; but on the oppofite fide of the gulf, on a more elevated fituation, and expofed to the fouth, there was, at the entrance of a wood, another village, confifting of eight cabins, much larger and better built than the firft. Above this, and at a very fmall diftance, were three yourts, or fubterraneous houfes, perfectly fimilar to thofe of the Kamtfchadales, defcribed in the third volume of Captain Cook's laft voyage; they were extenfive enough to contain the inhabitants of the eight cabins during the rigour of the cold feafon; befides, on fome of the fkirts of this village were feen feveral tombs, which were larger and better built than the houfes; each of them enclofed three, four, or five biers, of a neat workmanfhip, ornamented with Chinefe ftuffs, fome pieces of which were brocade. Bows, arrows, lines, and, in general, the moft valuable articles of thefe people, were fufpended in the interior of thofe monuments, the wooden door of which was clofed by a bar, fupported at its extremities by two props.

Their fole employment feemed to be the killing and curing of falmon, of which they eat raw, the fnout, the gills, the fmall bones, and fometimes the entire fkin, which they ftript off with infinite dexterity. When the ftript falmon were carried to the huts, the women, in the moft difgufting manner, devoured the mucilaginous part of them, and feemed to think it the moft exquifite food. Every cabin was furrounded with a drying place for falmon, which remain upon poles, expofed to the heat of the fun, after having been during three or four days fmoked round the fire, which is in the middle of their cabin; the women, who are charged with this operation, take care, as foon as the fmoke has penetrated them, to carry them into the open air, where they acquire the hardnefs of wood.

The bones of the falmon fo cured were fcattered, and the blood fpread round the hearth; greedy dogs, though gentle and familiar enough, licked and devoured the remainder. The naftinefs and ftench of this people are difgufting. There is not perhaps anywhere a race of people more feebly conftituted, or whofe features are more different from thofe forms to which we attach the idea of beauty; their middle ftature is below four feet ten inches, their bodies are lank, their voices thin and feeble, like that of children; they have high

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cheek bones, small blear eyes, placed diagonally; a large mouth, flat nose, short chin, almost beardless, and an olive coloured skin, varnished with oil and smoke. They suffer their hair to grow, and tie it up nearly the same as we do; that of the women falls loose about their shoulders, and the portrait which has just been drawn agrees equally well with their countenances as those of the men, from whom it would be difficult to distinguish them, were it not for a slight difference in the dress, and a bare neck; they are not, however, subjected to any labour, which might, like the American Indians, change the elegance of their features, if nature had furnished them with this advantage. Their whole cares are limited to the cutting and sewing their clothes, disposing of their fish to be dried, and taking care of their children, to whom they give the breast till they are three or four years of age.

With respect to dress, the men and little boys are clothed with a waistcoat of nankeen, or the skin of a dog or a fish, cut in the shape of a waggoner's frock. If it reach below the knee, they wear no drawers; if it do not, they wear some in the Chinese style, which fall as low as the calf of the leg. All of them have boots of seal's skin, but they keep them for the winter; and they at all times, and of every age, even at the breast, wear a leather girdle, to which are attached a knife in a sheath, a steel to strike a light with, a pipe, and a small bag to contain tobacco. The dress of the women is somewhat different; they are wrapped up in a large nankeen robe, or salmon's skin, which they have the art of perfectly tanning, and rendering extremely supple. This dress reaches as low as the ankle bone, and is sometimes bordered with a fringe of small copper ornaments, which make a noise similar to that of small bells. Those salmon, the skins of which serve for clothing, are never caught in summer, and weigh thirty or forty pounds.

Though they had neither priests nor temples, they seemed to be believers in sorcery, and took the motion of the Frenchmens hands, when writing, for signs of magic. Thus far they appeared savages.

Their sacred regard of property, their attention to their women, and the delicacy of their politeness to strangers, would, on the other hand, do honour to the most civilized nation. While Perouse and his people were in the bay, one of the families took its departure on a voyage of some length, and did not return during their stay. When he went away, the master of the family put some planks before the door of his house, to prevent the dogs from entering it, and in this state left it full of their effects. "We were soon (says our author) so perfectly convinced of the inviolable fidelity of these people, and their almost religious respect for property, that we left our sacks full of stuffs, beads, iron tools, and, in general, every thing we used as articles of barter, in the middle of their cabins, and under no other seal of security than their own probity, without a single instance of their abusing our extreme confidence; and on our departure from this bay, we firmly entertained the opinion, that they did not even suspect the existence of such a crime as theft."

Their attention to their women, so uncommon among savages, was displayed in their exempting them from hard labour; in their never concluding a bargain with the Frenchmen without previously consulting their wives; and in their reserving the pendent silver ear-rings and copper trinkets, which they purchased, for their wives and daughters. Of the delicacy of their manners to strangers, we shall give the following interesting instance in the words of Perouse's translator:

Observing with what repugnance they received presents, and how often they refused them with obstinacy, "I imagined (says Perouse) I could perceive, that they were perhaps desirous of more delicacy in the manner of offering them; and to try if this suspicion were well founded, I sat down in one of their houses, and after having drawn towards me two little children, of three or four years old, and made them some trifling caresses, I gave them a piece of rose-coloured nankeen, which I had brought in my pocket. The most lively satisfaction was visibly testified in the countenances of the whole family, and I am certain they would have refused this present, had it been directly offered to themselves. The husband went out of his cabin, and soon afterwards returning with his most beautiful dog, he entreated me to accept of it. I refused it, at the same time endeavouring to make him understand, that it was more useful to him than to me: but he insisted; and perceiving that it was without success, he caused the two children, who had received the nankeen, to approach, and placing their little hands on the back of the dog, he gave me to understand, that I ought not to refuse his children.

"The delicacy of such manners cannot exist but among a very polished people. It seems to me, that the civilization of a nation, which has neither flocks nor husbandry, cannot go beyond it. It is necessary to observe, that dogs are their most valuable property; they yoke them to small and very light sledges, extremely well made, and exactly similar to those of the Kamtschadales. These dogs, of the species of wolf dogs, and very strong, though of a middle size, are extremely docile, and very gentle, and seem to have imbibed the character of their masters."

ORTHODROMICS, in navigation, is great-circle sailing, or the art of sailing in the arch of a great circle, which is the shortest course: For the arch of a great circle is *orthodromia*, or the shortest distance between two points or places.

ORYCTEROPUS, the name given by M. Geoffroy, professor of zoology in the French museum of natural history, to the animal called by other zoologists *Myrmecophaga Capensis*. (See MYRMECOPHAGA, *Encycl.*) He considers it as a distinct genus, and seems indeed to have proved, by a comparison of the organs of the orycteropus with those of the *tatous dasypus* of Linnæus, and of the *myrmecophagi*, that this genus is intermediate, by its forms and habits, between those two families. It approaches to the *tatous* in its organs of mastication, and the form of the toes and nails, and in having a short and single cæcum, whilst that of the myrmecophagi is double, as in birds, by the reuniting of the bones of the os pubis, which are not articulated together in the myrmecophagi. The orycteropus, however, bears a relation to the last, since it has, like them, a very small mouth, whence its tongue, covered with hair, may be protruded to a considerable length. Finally, the habits of the orycteropus resemble those of the animals to which it approaches the most; it does not climb trees, but lives under the earth like the tatous;

tous; it feeds like them on roots, but alfo it hunts after anthills, like the myrmecophagi. Its fnout terminates in a blunt callous; a character which is peculiar to it. It may be diftinguifhed in the works of naturalifts by the following defcription:

Oryćteropus. Molar teeth (fix) with flat vertices; the body covered with hair.

The oryćteropus, as appears from the preceding, connects the tatous with the myrmecophagi and with the *pangolin manis* of Linnæus. The large foffile fpecies found in Paraguay, for which Citizen Cuvier has eftablifhed a new genus, under the name of *megatherium*, is intermediate between the floth and the myrmecophagus; and, laftly, the aftonifhing animal of New Holland, covered with briftles like the porcupine, fupported by very fhort legs, and of very fingular conformation, and with a head round at the occiput, terminating in a fnout, without teeth, very flender, long, and cylindrical, and defcribed by Mr George Shaw under the name of myrmecophaga aculeata, appears to have very ftriking relations to the pangolin and the oryćteropus: from hence it follows, that in confequence of thefe important acquifitions, we ought for the future to count, in the number of our natural orders, that of the *edentated*, or *edented*, confifting of the following genera: *Dafypus oryćteropus myrmecophaga*, and *aculeata, manis, myrmecophaga, megaterium* et *bradypus*.

OSCILLATION, in mechanics, vibration, or the reciprocal afcent and defcent of a pendulum.

Axis of OSCILLATION, is a line parallel to the horizon, fuppofed to pafs through the centre or fixed point about which the pendulum ofcillates, and perpendicular to the plane in which the ofcillation is made.

Centre of OSCILLATION, in a fufpended body, is a certain point in it, fuch that the ofcillations of the body will be made in the fame time as if that point alone were fufpended at that diftance from the point of fufpenfion. Or it is the point into which, if the whole weight of the body be collected, the feveral ofcillations will be performed in the fame time as before: the ofcillations being made only by the force of gravity of the ofcillating body.

OSCULATION, in geometry, denotes the contact between any curve and its ofculatory circle; that is, the circle of the fame curvature with the given curve, at the point of contact or of ofculation. See INVOLUTION in this *Suppl.*

OSCULATION alfo means the point of concourfe of two branches of a curve which touch each other. For example, if the equation of a curve be $y = \sqrt{x} + \sqrt[4]{x^5}$, it is eafy to fee that the curve has two branches touching one another at the point where $x = 0$, becaufe the roots have each the figns + and −.

OUADELIM, and LABDESSEBA, two tribes of Arabs inhabiting the *Sahara* or Great Defart of Africa, of whom almoft nothing was known to Europeans till the publication of Briffon's narrative of his fhipwreck and captivity among the latter tribe. He defcribes the Ouadelim and Labdeffeba as the moft formidable of all the interior tribes of Arabs, and as often extending their ravages to the very gates of Morocco. "Their hordes (he fays) are frequently intermingled with thofe of the Roufege, Rathidium, Chelus, Tucanois, and Ouadeli tribes, as they have no diftinct boundaries, and change their habitations as the defart affords pafturage and water. They are tall, handfome, ftout, and vigorous men. Their hair is briftled, and their nails, which they often ufe in battle, as long as claws; large hanging ears and a long beard give them a ftern ferocious air. The Ouadelim in particular are fierce, arrogant, and warlike, but foon difpirited by obftinate refiftance, efpecially when they have not a decided fuperiority in numbers. In their hordes they lodge by families, in tents which are covered with a thick cloth of camels hair, which the women fpin and weave upon a loom fo fmall, that they work fitting on the ground. The furniture of their tents confift of two large facks of leather, in which they keep old clothes and pieces of old iron, three or four goat fkins for holding milk and water, two large ftones for grinding their barley, a fmaller one for driving the pins of their tents, an ozier matting which ferves for a bed, a thick carpet for a covering, a fmall kettle, and fome wooden difhes, with pack faddles for their camels. The perfon who, befides thefe articles, poffeffes a few horfes, camels, fheep, and goats, is reckoned wealthy, as there are many Arabs who only poffefs fheep and goats. Except fore eyes and the cholic, they are fubject to few endemic difeafes. The firft diforder is caufed by the reflection of light from the burning fands of the defart, the other proceeds from the verdigreafe which contaminates all their victuals. Their kettles are not tinned, and never wafhed, fo that they are quite crufted over with verdigreafe, the virulence of which is probably diminifhed by the quantity of milk they ufe. When they refide long in one place, they fometimes plough the fpots which are moiftened by the rain, and fprinkle them with feed in a carelefs manner. Plentiful crops are often thus produced; but inftead of waiting till the grain attains maturity, they cut it down, and dry it over hot cinders. Treachery and perfidy are the innate vices of the Arabs; affaffinations are frequent; no man trufts the promife of another; no man makes a written agreement, as the poignard cancels all bonds and obligations. The men often relate their exploits to each other; the embellifhing of a ftory is fucceeded by a charge of falfehood, and the poignard folves every difficulty. The ancient rites of hofpitality, however, are practifed among thefe tribes in their utmoft extent. The Arab, who in the field is a rapacious plunderer, becomes liberal and generous as foon as he enters his tent. War is only a fpecies of rapine, and the victory is decided at the firft fhock. The Arab is devoid of fanguinary courage; he attacks only to plunder, and never thinks that booty is to be put in competition with his life. When the battle is ended, each party makes graves for the flain, and enclofe the tombs with mounds of ftones. The ages of the warriors are denoted by the fpace of ground which the grave occupies, and the funeral proceffion is clofed by the howls of the females.

"The women never affume the name of their hufbands, and never eat with them at meals. They are faithful to their hufbands, and cannot be divorced except by the decree of the feniors of the horde. The Arabs difplay their opulence by the ornaments of their women, whofe ears, arms, and legs, are generally adorned with rings of gold and filver. An Arab beauty muft have long teeth fhooting out of her mouth, a body extremely thick, and limbs of the longeft fize. At the birth of a fon, every woman, to teftify her joy, blackens

Ouadelim. er, her face for 40 days. At the birth of a daughter, she only daubs the half of her face during the space of 20 days. A mother treats her son with the same respect as her husband, almost as soon as he is able to walk; she prepares his food, serves him, and eats when he has finished his repast. In the education of their young men, the most important acquisitions are, dexterity in the use of the poignard, skill in embowelling their enemies with their long nails, and a plausible air in uttering a falsehood. More rude and ferocious than the tribes whose territories lie upon the shore of the sea, the Labdesséba and Ouadelim Arabs are also more confined and illiberal in their ideas, not only believing that they are the first nation in the world, but fancying that the sun rises only for them. Brisson relates, that some of them expressed this idea in unequivocal terms. 'Behold (said they) that luminary, which is unknown in thy country. During the night, thou art not enlightened, as we are, by that heavenly body, which regulates our days and our fasts. His children (the stars) point out to us the hours of prayer. You have neither trees nor camels, sheep, goats, nor dogs. Are your women similar to ours?' 'How long didst thou remain in the womb of thy mother (said another)?' 'As long (replied Brisson) as thou in that of thine.' 'Indeed (said a third, counting the fingers and toes of the Frenchman) he is made like us: he differs only in his colour and language.' 'Do you sow barley in your houses?' said the Arabs, alluding to the ships of the Europeans 'No (said Brisson), we sow our fields almost in the same season as you.' 'How! (cried several) do you inhabit the earth? we believed that you were born and lived upon the sea.' These Arabs, according to the Turkish proverb, believe that all the world is like their father's house: unacquainted with the manners of other nations, and unaccustomed to reflect upon the causes of national character, every variation from their own customs appears not only ridiculous, but monstrous; every difference of opinion not only absurd, but criminal. This ignorance of the Arabs, conjoined with their local and religious prejudices, enables us to account for the insulting treatment which Brisson and his companions received, without having recourse to inherent depravity of nature." That treatment was indeed shocking.

Brisson had surrendered himself, on his shipwreck, to Sidi Mahomet, a *Talbe* or priest of the tribe of Labdesseba. During the absence of the priest, the Labdesseba, who guarded the captives, were attacked and maltreated by a party of the Ouadelims, and during the battle which ensued, Brisson had almost lost his life. Instead of compassionating his forlorn situation, the women threw sand into his eyes, as they said, to dry his eye lids. The Arabs, into whose hands he had fallen, had only come down to the sea-coast to gather wild grain, three days before the shipwreck; and to preserve their booty, they immediately retreated to the interior part of the desart. A guide preceded the horde, to place at intervals small pyramids of stone, to direct their course, at a distance from every hostile tribe After passing some very high mountains, wholly covered with small greyish pebbles as sharp as flints, they descended into a sandy plain overspread with thorns and thistles. When Brisson was unable to walk, on account of the bleeding of his feet, he was mounted on a camel; the bristly hair and hard trot of which Ouadelim. soon excoriated him so much, that the blood run copiously down its flanks. By throwing heated stones into a wooden vessel, filled with barley meal, diluted with water procured on the sea-shore, preserved in a goat's skin, and mixed with pitch to prevent putrefaction, the Arabs prepared a kind of soup, which they kneaded with their hands, and ate unchewed. They roasted a goat in heated sand, ate its fat raw, and, after having devoured the flesh, gnawed the bones, and scraped them with their nails, threw them to Brisson and his companions, desiring them to eat quickly, and load the camels, that the journey might not be impeded. Proceeding eastward, they crossed a vast plain, covered with small stones white as snow, round and flat as a lentil, where not a single plant was produced. The earth beneath their feet resounded dull and hollow, and the small stones pricked them like sparks of fire. The reflection of the rays of the sun from the sand was scorching; the atmosphere was loaded with a red vapour, and the country appeared as if filled with flaming volcanoes. Neither birds nor insects could be seen in the air. The profound silence was frightful. If a gentle breeze ever arose, it produced extreme languor, chopping of the lips, burning heat of the skin, with small smarting pimples This plain was even shunned by wild beasts. After traversing this plain, they entered another, where the wind had thrown up in furrows the sand, which was of a reddish colour. On the tops of the furrows grew a few sweet-scented plants, which were devoured by the camels. On quitting this sandy plain, they entered a valley surrounded by mountains, where the soil was white and slimy, and where they found water of a noxious smell, covered with green moss, and soon after discovered a horde of the friendly tribe Roussye.

After another journey of sixteen days, they arrived at the tents of the Labdesseba horde, to which Sidi Mahomet belonged. The tents pitched among thick bushy trees, and the numerous flocks feeding along the sides of the hills, presented at a distance an aspect of happiness and pastoral simplicity. On approaching near, the trees of beautiful green foliage proved to be only old gummy stumps, almost void of branches, so encircled with thorns that their shade was inaccessible. The women approached, with loud cries and the most fawning servility, to welcome their tyrants, to throw stones at the Christians, and spit in their faces, while the children imitated the example of their mothers. Brisson, who endeavoured to ingratiate himself with his master's favourite, not only failed in this, but incurred her implacable resentment, through his irritability, which to the Arab women seemed extremely to resemble petulance. During his residence with Sidi Mahomet, the hardships he endured were almost incredible. With the excessive heat, the milk of the sheep, goats, and camels, diminished, and then the dogs fared better than the Christians, who were forced to subsist on wild herbs and raw snails. When the rains fell, and the least pressure made the water to spring up through the sandy soil, the Christians slept behind a bush, unsheltered, on the bare ground. Brisson and his master sometimes reasoned about religion; when the latter always answered the harangues of the former by declaring, that he preferred a bowl of churned milk to such

absurdities. Several of his companions perished, and were left by the Arabs to be devoured by the ravens, while in the struggles of death. One of them was supposed to be murdered by his master for milking his camels clandestinely. An application made by Brisson to the consul at Mogador, by a letter entrusted to a Jewish merchant, was frustrated through the negligence of the vice-consul; and the Labdesseba Arabs thought the journey too dangerous to be encountered for the ransom of their slaves. He was, however, at last relieved, through the humanity of his master's brother-in-law, who carried him to Morocco, where his ransom was paid by the Emperor, and whence he returned to France. For a fuller account of these two savage tribes, see *Saugnier's and Brisson's Narratives*; or a very pleasing *Historical and Philosophical Sketch of the Discoveries, &c. of the Europeans in Northern and Western Africa*, published 1790 by *Symington* Edinburgh, and *Vernor* and *Hood* London.

OXYGLYCUS CERASUS, the name given by the editor of Dalzel's History of Dahomy to a very singular fruit produced in that country, as well as in some other parts of Africa. It resembles a small olive in every respect but the colour; being of a dusky reddish hue, changing at the end next the stalk to a faint yellow. The pulp is firm, and almost insipid; the stone is hard like that of the olive. After having chewed one or more of such berries, and spit out or swallowed the pulp at pleasure, a glass of vinegar will taste, to the person trying the experiment, like sweet wine; a lime will seem to have the flavour of a very ripe China orange; and the same change is produced on other acids, the ordinary effects of which upon the palate is destroyed in a very unaccountable manner, without effervescence or any sensible motion. Indeed, the effect is very different from neutralization, arising from the mixture of acid and alkali; such combination producing a neutral saline liquor, whilst this miraculous berry seems to convert acids to sweets. Food or drink, not containing any acid, suffer no change by the previous use of this fruit; its effect upon acids continues, even after a meal, though in a much smaller degree. The natives use it to render palatable a kind of gruel called *guddoe*, which is made of bread after it becomes too stale for any other purpose. They describe it as the fruit of a large tree.

Plants six or seven inches high were raised from this fruit by Mr Dalzel, who tried to carry them from Angola to the botanic garden at St Vincent's; but they died on the passage. He preserved the berries in spirits, in syrup, and in a dry form; but they lost their singular quality in all those preparations. The plant is an evergreen, and the leaves in this infant state are like those of the olive.

OXY-MURIATIC ACID (See CHEMISTRY-*Index* in this *Suppl.*), is the principal agent in the new process of bleaching (see BLEACHING, *Suppl*); but, till very lately, at least, if not even at present, the bleachers were in the practice of adding some alkali to the acid, notwithstanding the strong objections which M. Bertholet made to that addition, and notwithstanding the proofs urged by Mr Rupp, that it increases the expence of bleaching about 40 *per cent*. The chief reason for persisting in a practice to which such objections were urged was, that the addition of the alkali deprives the liquor of its suffocating effects without destroying its bleaching powers. Mr Rupp, however, has contrived the following apparatus, in which may be safely used the pure oxy muriatic acid simply dissolved in water, which is at once its cheapest and best vehicle.

Figure 1. (Plate XLI.) is a section of the apparatus. It consists of an oblong deal cistern ABCD, made water-tight. A rib EE of ash or beech wood is firmly fixed to the middle of the bottom CD, being mortised into the ends of the cistern. This rib is provided with holes at FF, in which two perpendicular axes are to turn. The lid AB has a rim GG, which sinks and fits into the cistern. Two tubes HH are fixed into the lid, their centres being perpendicularly over the centres of the sockets FF when the lid is upon the cistern. At I, is a tube by which the liquor is introduced into the apparatus. As it is necessary that the space within the rim GG be air tight, its joints to the lid, and the joints of the tubes, must be very close; and, if necessary, secured with pitch. Two perpendicular axes KL, made of ash or beech wood, pass thro' the tubes HH, and rest in the sockets FF. A piece of strong canvas M is sewed very tight round the axis K, one end of it projecting from the axis. The other axis is provided with a similar piece of canvas. N are pieces of cloth rolled upon the axis L. Two plain pulleys OO are fixed to the axes, in order to prevent the cloth from slipping down. The shafts are turned by a moveable handle P. Q is a moveable pulley, round which passes the cord R. This cord, which is fastened on the opposite side of the lid (see fig. 2.), and passes over the small pulley S, produces friction by means of the weight T. By the spigot and fausset V, the liquor is let off when exhausted.

The dimensions of this apparatus are calculated for the purpose of bleaching twelve or fifteen pieces of $\frac{7}{8}$ calicoes, or any other stuffs of equal breadth and substance. When the goods are ready for bleaching, the axis L is placed on a frame in an horizontal position, and one of the pieces N being fastened to the canvas M by means of wooden skewers, in the manner represented in fig. 1. it is rolled upon the axis by turning it with the handle P. This operation must be performed by two persons; the one turning the axis and the other directing the piece, which must be rolled on very tight and very even. When the first piece the axis, the next piece is fastened to the end of it by skewers, and wound on in the same manner as the first. The same method is pursued till all the pieces are wound upon the axis. The end of the last piece is then fastened to the canvas of the axis K. Both axes are afterwards placed into the cistern, with their ends in the sockets FF, and the lid is put on the cistern by passing the axes through the tubes HH. The handle P is put upon the empty axis, and the pulley Q upon the axis on which the cloth is rolled, and the cord R, with the weight T, is put round it and over the pulley S. The use of the friction, produced by this weight, is to make the cloth wind tight upon the other axis. But as the effect of the weight will increase as one cylinder increases and the other lessens, Mr Rupp recommends that three or four weights be suspended on the cord, which may be taken off gradually as the person who works the machine may find it convenient. As the weights hang in open hooks, which are fastened to the

Oxy-Muriatic Acid.

the cord, it will be little or no trouble to put them on and to remove them.

Things being thus disposed, the bleaching liquor is to be transferred from the vessels in which it has been prepared into the apparatus, by a moveable tube passing through the tube I, and descending to the bottom of the cistern. This tube being connected with the vessels, by means of leaden or wooden pipes provided with cocks, hardly any vapours will escape in the transfer. When the apparatus is filled up to the line *a*, the moveable tube is to be withdrawn, and the tube I closed. As the liquor rises above the edge of the rim G, and above the tubes HH, it is evident that no evaporation can take place, except where the rim does not apply closely to the sides of the box; which will, however, form a very trifling surface if the carpenter's work be decently done. The cloth is now to be wound from the axis L upon the axis K, by turning this; and when this is accomplished, the handle P and pulley Q are to be changed, and the cloth is to be wound back upon the axis L. This operation is, of course, to be repeated as often as necessary. It is plain, that by this process of winding the cloth from one axis upon the other, every part of it is exposed, in the most complete manner, to the action of the liquor in which it is immersed. It will be necessary to turn, at first, very briskly, not only because the liquor is then the strongest, but also because it requires a number of revolutions, when the axis is bare, to move a certain length of cloth in a given time, though this may be performed by a single revolution when the axis is filled. Experience must teach how long the goods are to be worked; nor can any rule be given respecting the quantity and strength of the liquor, in order to bleach a certain number of pieces. An intelligent workman will soon attain a sufficient knowledge of these points. It is hardly necessary to observe, that, if the liquor should retain any strength after a set of pieces are bleached with it, it may again be employed for another set.

With a few alterations, this apparatus might be made applicable to the bleaching of yarn. If, for instance, the pulley O were removed from the end of the axis K, and fixed immediately under the tube H;—if it were perforated in all directions, and tapes or strings passed through the holes, skains of yarn might be tied to these tapes underneath the pulley, so as to hang down towards the bottom of the box. The apparatus being afterwards filled with bleaching liquor, and the axis turned, the motion would cause every thread to be acted upon by the liquor. Several axes might thus be turned in the same box, and being connected with each other by pulleys, they might all be worked by one person at the same time; and as all would turn the same way and with the same speed, the skains could not possibly entangle each other.

P.

Painting.

ENCAUSTIC PAINTING is an art of very high antiquity, which, after being lost for many ages, was restored, as is commonly believed, by the celebrated Count Caylus, whose method was greatly improved, first by Mr Josiah Colebrooke, and afterwards by Miss Greenland, who brought the rudiments of her knowledge from Italy (See ENCAUSTIC, *Encycl.*). In that country encaustic painting had employed the attention of various artists and men of learning, such as Requeno, Lorgna, and Astori, &c; but the best account of it that has fallen under our notice, is in that valuable miscellany called the *Philosophical Magazine*, taken from a work of Giov. Fabbroni, published at Rome in the year 1797.

According to this author, "the knowledge and use of encaustic painting is certainly older than the time of the Greeks and the Romans, to whom the learned Requeno seems to assign the exclusive possession of this art; because the Egyptians, who, with the Etruscans, were the parents of the greater part of the inventions known among mankind, and from whom the Greeks learned so much, were acquainted with and employed encaustic painting in the ancient ages of their greatness and splendour, as is proved by the valuable fragments of the bandages and coverings of some mummies which he had examined. No oil-painting (he says), of only two or three hundred years old, exhibits a white paint which has kept so well as that seen on these fragments; and this circumstance sufficiently proves the superiority of the encaustic method over the common oil-painting, which, notwithstanding the general opinion, cannot, he thinks, have been unknown to the ancients.

"It is impossible (says he) that in Egypt and Phoenicia, where so much use was made of flax, the oil procured in abundance from that plant should have been unknown. Those who have kept oil, or who have spilt any of it, whether nut or linseed oil, must have remarked that it possesses the property of soon drying by the effects of the atmosphere; and therefore it may be easily believed that mankind must soon have conceived the idea of employing it, particularly for ships, which, as Herodotus says, were painted with red ochre in the earliest periods, and adorned with figures and ornaments. The use of oil afforded painting a much simpler and easier method than that of wax; it must therefore have been first adopted, and the transition from oil to wax must be considered as a step towards bringing the art to perfection; because encaustic painting is not exposed to the irremediable inconveniences that arise in oil-painting, the value of which we extolled through ignorance, and praised as a new invention.

"Oil in general, and in particular drying oil which the painters use, has naturally a strong inclination to combine itself with the vital air or oxygen of the atmosphere, and by imbibing oxygen it becomes dry, and assumes the character of resin; but the colour then becomes darker, as is the case with transparent turpentine, which gradually becomes a black pitch.

"Accord-

Painting.

"According to the new and more accurate method of decomposing bodies, oil consists principally of hydrogen and carbon. By coming into contact with the atmosphere, and absorbing its oxygen and light, it undergoes a slow and imperceptible combustion, which is not essentially different from the speedy and violent one which it would undergo in the common mode of burning. It first passes, by imbibing oxygen, into the state of a more or less dark resin; loses gradually its essential hydrogen, which makes a new combination, and afterwards the oxygen itself which has attracted the carbon; and at length leaves behind a thin layer of actual carbon, which in the end becomes black in the course of time, and considerably obscures the oil painting. By a continuance of the before-mentioned slow combustion, the carbon itself, as it were, burns also: if it be strongly acted upon by the light, it attracts the oxygen of the atmosphere, and again brings forward the carbonic acid or fixed air, which gradually flies off. By this, which I may call the second degree of combustion, the painting must become dusty and friable, like crayon *painting*.

"Hence it appears (says our author) that one can hope only for a transient or deceitful effect from the refreshing of oil-paintings with oil; because the harmony of the tones, which the painter establishes as suited for the moment, does not proceed with equal steps, and cannot preserve itself in the like measure for the course of a few years, as each tint, as they say, ought to increase, or, to speak more properly, to burn in proportion to its antiquity. It thence follows, that mere washing may be prejudicial to an old painting; and that the method of refreshing paintings, as it is called, by daubing over the surface, from time to time, with new drying oil, is highly prejudicial and ill calculated for the intended purpose, since the oil when it becomes dry contracts in its whole surface, carries with it the paint under it, and occasions cracks in the painting. New oil of this kind gives occasion to mineral paints to be restored; but covers the picture with a new coat of resin, and then of carbon, which arises from the gradual combustion, and always causes more blackness, and the decay of the painting which one wishes to preserve.

"Wax, on the other hand, undergoes a change which is very different from that of drying oil. The wax, instead of becoming black by the contact of the atmosphere, increases in whiteness, and, according to its natural quality, is not decomposed in the air, and it does not strongly attract the oxygen of the calces or metallic ashes which are commonly used in painting. Moreover, the so called earths, which are in themselves white, and are never variable either by the presence or absence of oxygen, cannot be employed in oil-painting, because that fluid makes them almost transparent, and causes them to remain as it were without body, and not to produce the wished for effect. That beautiful white, which may be observed on the before mentioned Egyptian encaustic, is nothing else than a simple earth, and according to our author's chemical experiments, a chalk which is also unalterable."

That the ancients were once acquainted with the use of oil-painting, and neglected it on account of the great superiority of the encaustic method, our author thinks farther evident from the different accounts which we have of the ancient paintings. "Thus Petronius praises the fresh appearance which the valuable works of Zeuxis and Apelles had, even in his time; but Cicero, on the other hand, speaks of the painting, of the ancients having suffered from blackness. The former speaks of wax-painting, and the latter certainly alludes to paintings in oil. It is well known that paintings with wet chalks or water colours do not become black by age, and that this is the case also with encaustic. Of this any one may be convinced, not only by the expressions of the above quoted authors, but by one's own eyes on surveying the Egyptian fragment alluded to. Galland proves, on various grounds, that a painting was made with oil so early as the reign of Marcus Aurelius; and if no specimens of that period have reached us, this is perhaps to be ascribed to the frail and perishable nature of this species of painting."

Sign. Fabbroni, after some farther observations, calculated to prove that metallic oxyds or calces could not have been employed as pigments on such mummies as still retain their colours fresh, proceeds thus: "Those who are acquainted with the accuracy and certainty of the method not long since introduced into chemical operations, will be convinced, that in 24 grains of the encaustic painting, which I ventured to detach from the above mentioned Egyptian fragment, in order to subject it to examination, the mixture of an hundredth part of a foreign substance would have been discovered with the greatest certainty; that the resin of Requeno must undoubtedly have been perceptible to me, and that the alkali of Bachelier and Lorgna could not have escaped the counteracting medium. But in this Egyptian encaustic I found nothing except very pure wax, though I varied my analysis in every known method. I must therefore conclude, that modern learned writers, at least in respect to this Egyptian mode of painting, were as far from the truth as the accounts of ancient authors appear to me precise and satisfactory; and that the encaustum with which formerly the fore part of ships and the walls of houses and temples were painted, was something different from soap or resinous crayons.

"I am well aware that it will be asked, In what manner can wax at present be rendered sufficiently liquid for the strokes of the pencil, if it be not converted into powder or soap? This question, in my opinion, can be fully answered from the words of an ancient author, and, in the next place, by experience.

"Vitruvius in particular, book vii. chap. ix. expresses himself in the following clear manner:

'Those (says he) who wish to retain cinnabar on walls, cover it, when it has been well laid on and dried, with Punic wax diluted in a little oil (let this be well remarked); and after they have spread out the wax with a hair brush, they heat the wall by means of a brazier filled with burning coals (hence it is called encaustic painting), and then make it smooth and level by rubbing it with wax tapers and clean cloths, as is done when marble statues are covered with wax. The effect of this wax crust is, that the colour is not destroyed by the light of the sun or the moon (A).'

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(A) The reader will find the original of this passage, with a translation somewhat different, in the article ENCAUSTIC, *Encycl.*

"It here appears, that the Romans, who copied the Grecian process, which the latter borrowed from the Egyptians, mixed the wax with an oil to make it pliable under the brush; but no mastic, alkali, or honey, as has been ingeniously imagined, and which some have thought might be employed with success. The difficulty now will be confined to point out in what manner this oil was employed. It does not appear that they used those fat oils which are commonly called drying oils; because they could have employed these as we do, without the addition of wax, which, in such a case, would have been entirely superfluous. Fat oils which do not dry would not have been proper for that purpose, as they would have kept the wax continually in the state of a soft pomade or salve. Besides, my experiments (continues the author) would without doubt have shewn me the existence of any oily matter.

"With regard to essential or volatile oils, a knowledge of them is not allowed to the ancients, as the invention of distilling is not older than the eighth or ninth century, and therefore falls in with the period of Geber or Avicenna" Yet it is certain, that, in order to use wax in their encaustic painting, they must have combined it with an ethereal volatile oil, of which no traces should afterwards remain; because this was necessary for the solidity of the work, and because no oil was found in the fragment that was examined. But naphtha is such an oil, much lighter (says our author) than ether of vitriol itself. It is exceedingly volatile, and evaporates without leaving a trace of it behind. On this account it is used when signatures and manuscripts are to be copied; because the paper, which is moistened by it, and so rendered transparent, quickly becomes white and opaque as before by the complete evaporation of the naphtha. That the Assyrians, Chaldeans, and Persians, were well acquainted with the properties of naphtha is known to every scholar; and hence our author thinks it highly probable that it was used by those nations to render wax fit for painting. "It appears to me (says he) that the Greeks, as was the case with many other things, learned encaustic from the Egyptians, who probably derived it from the Assyrians or Chaldeans; and if so, we have discovered the real mixture used for ancient encaustic painting."

To put the matter, however, beyond a doubt, Sign. Fabbroni prepared, for an eminent Saxon painter, a solution of Venetian wax in highly purified naphtha, desiring him to mix up with it the colours necessary for a painting. The artist complied; and both he and our author were astonished, as well as all their friends, at the high tone which the colours assumed, and the agreeable lustre which the painting afterwards acquired when it had been rubbed over with a soft cloth. A similar solution of wax was made for another artist, in which the spirit of turpentine was used instead of naphtha with equal success. Our author therefore concludes, we think with reason, that if he has not discovered the real composition employed by the ancients in their encaustic paintings, he has at least approached much nearer to that discovery than any of his predecessors who have employed their learned labours in the same field of investigation.

PAINTINGS, or PICTURES, are often done upon objects from which, when they are valuable, it would be desirable to transfer them. Thus, a connoisseur in painting might naturally wish to transfer an old and valuable picture from the ceiling or walls of his room to stretched canvas; and such a man would consider himself as deeply indebted to the artist who should perform so arduous a task. This task has actually been performed by Mr *Robert Salmon* of Woburn, Bedfordshire, who was honoured by the *Society for the Encouragement of Arts, &c.* with the greater silver pallet, for communicating the method by which he accomplished it.

"The first thing (says Mr Salmon) to be attended to with respect to paintings, either on plastered walls or ceilings, or on boards, is, that the place in which they are be secure from wet or damp. If the paintings are on old walls in large buildings, or other places where this cannot be attained by art, then the summer season should be taken for the purpose, as the picture will rarely escape damage, if wet or damp gets at it while under the process. At the same time, care should be taken that the room, or other place, be not overheated; as that would produce equally bad effects.

"These precautions being taken, the next thing is to examine the surface of the painting. If there are any holes in the same, they must be carefully filled up with a paste or putty, made of glue and whiting: this, if the holes are large, should be twice or thrice done, so as entirely to fill them up, and leave the surface even and smooth; but if there are any bruised places, with paint still remaining on the surface of the bruised parts, then this stopping must not be applied, but the securing canvas, hereafter described, must be pressed down into these places. In the places that are stopped, there will of course appear blemishes when the picture is transferred; but the process is rendered much more certain and sure by being so done. Attention must next be paid to lay down any blisters, or places where the paint is leaving the ground: this is done by introducing, between the paint and the ground, some very strong paste of flour and water; and the surface of the blistered paint being damped with a wet sponge or brush, it may be pressed with the hand home to the ground, to which it will then adhere.

"All the unsound places being thus secured, care must be taken to clear the surface of any grease or dirt, as also of any particles of the paste that may happen to be left on it. The next thing is, to determine the size of the painting meant to be taken off: If it is on a plain surface, a board of the size of the picture must be procured, not less than an inch in thickness, and framed together with well seasoned wood, in small pannels, smooth and flush on one side. This done, a piece of fine open canvas must be provided, such as the finest sort used for hanging paper on; which canvas is to be somewhat larger than the picture, and so sewed together, and the seam so pressed, that it be perfectly smooth and even. This is what Mr Salmon calls the securing canvas; which, being so prepared, is to be stuck on the surface of the picture with a paste made of strong beer, boiled till it is half reduced, and then mixed with a sufficient quantity of flour to give it a very strong consistence. To large pictures on walls or ceilings, the canvas must for some time be pressed, and rubbed with the hand as smooth as possible, working it from the middle to the outside, so as to make it tolerably tight; observing, as it dries, to press it, with the hand or a cloth, into any hollow or bruised places, so that

Paintings. that it may adhere to every part of the painting: this done, it is left to dry; which it will generally do in a day or two. When dry, a fecond canvafs, of a ftronger and clofer fort, and of the fame fize as the other, is in like manner to be attached on the top of the firft. This laft will want very little attention, as it will readily adhere to the firft; and, being dry, attention muft be paid to take off any fmall knots or unevennefs that may be upon the furface of it; which done, the whole fhould be again covered with a thin pafte of fize and whiting; which is to be pumiced over when dry, fo as to make the whole perfectly fmooth and even.

"The painting being thus fecured, the board, already prepared to the fize of the picture, is to be put with the fmooth fide againft the furface thereof, fo as exactly to cover as much as is intended to be transferred. The edges of the canvas, which, as before directed, is to be larger than the painting, are then to be pulled tight over, and clofely nailed to the edge of the board. If the painting is large, and either on a ceiling or wall, the board muft, by proper fupports, be firmly fixed againft it, fo that it can readily be lowered down when the plafter and painting are detached.

"The canvas and board being fixed, the painting is to be freed from the wall or ceiling, together with a certain portion of the plaftering: this, with proper care and attention, may be readily done. If on a ceiling, the firft thing is to make fome holes through the plaftering, round the outfide of the board and painting; and, with a fmall faw, to faw the plaftering from one hole to another, till the whole is difunited from the other parts of the ceiling: this done, the workman muft get at the upper fide of the ceiling, where he muft free the plaftering from the laths, by breaking off the keys thereof, and with a chifel cut out the laths; whereby the plaftering, together with the picture, will be left refting on the board and fupports.

"If the painting is on a brick or ftone wall, the wall muft be cut away at top, and down the fides of the painting; and then, by means of chifels or faws in wooden handles, of different lengths, the wall muft be cut away quite behind the painting; leaving the fame, together with the plaftering, refting on the board. This operation may fometimes be done with a faw; or, if the wall be not thick, nor the other fide of much confequence, the bricks or ftones may be taken out from that fide, leaving the plaftering and painting as before. This laft method (fays the author) I have not practifed: the other, of cutting away fome part of the wall, I have, and fee no difficulty, or very great labour, in the operation; but that, of courfe, muft be various, according to the texture of the wall and mortar.

"If the paintings are on curved furfaces, fuch as the coves of ceilings, then the only difference of operation is, that fome ribs of wood muft be cut out, and boarded fmooth to the curve of the furface of the painting, and then fixed up thereto, in place of the before defcribed bearing-board; the painting is then to be freed, and left with the plaftering, refting on the bearers.

"For paintings on wainfcot or boards, the fame fecuring and procefs is to be exactly followed; only that, as the wainfcot or board can always be cut to the fize wanted, and laid horizontal, the fecuring canvas is to be ftretched thereon, and turned over the edges of the fame, till it is dry; after which, the edges are again to be turned up, and nailed to the board, in the fame manner as with refpect to paintings from walls.

"Having, as before defcribed, in any of the aforementioned cafes, freed the paintings from their original places, you have got them fecured to two thickneffes of canvas, with their furfaces on the board prepared for that purpofe; this being the cafe, they can readily be removed to any room or fhop, to be finifhed as follows: Having carried the painting into the fhop or room, which fhould be moderately warm and dry, but by no means overheated, lay the board on a bench or treffels, fo that the back of the picture be uppermoft: the plaftering or wood, as may happen, is then to be cleared away, leaving nothing but the body of paint, which will be firmly attached to the fecuring-canvafs. To perform this, a large rafp, a narrow plane, and chifels, will be requifite. This operation, though difficult to be defcribed, would foon be learned by any one who fhould make the attempt; nor is it very tedious; and fo performed, the picture is ready to be attached to its new canvas, as follows.

"The painting being cleared, and lying on the board, the back thereof is to be painted three or four times over fucceffively, with any good ftrong-bodied paint, leaving one coat to dry before another comes on: a day or two between each will generally be found fufficient. Each of thefe coats, and particularly the firft, fhould be laid on with great care, taking but a fmall quantity in the brufh at a time, and laying it very thin. This precaution is neceffary, to prevent any of the oil or paint from paffing through any fmall cracks or holes in the furface of the picture; as fuch oil or paint would run into the pafte, and fo attach the fecuring canvas to the picture, as to prevent its being afterwards got off. If any fuch holes or cracks are obferved, they fhould be ftopped up with the glue and whiting pafte, and the painting then repeated, till a complete coat is formed on the back of the picture. It is then ready for attaching to its canvas, which is done by fpreading all over the picture a pafte made of copal varnifh, mixed with ftiff white lead, and a fmall quantity of any other old fat paint; all which being fpread equally over with a pallet knife, fuch a canvas as the firft fecuring canvas is laid thereon, and ftrained and nailed round the edges of the board; in which ftate it is left till it becomes tolerably dry: then a fecond canvas, of a ftronger fort, muft be in like manner attached on the firft, and left till it is perfectly dry and hard. This generally takes about two months; and the longer the painting is left, the more fecurely it will be attached to its canvas, and lefs liable to crack or fly therefrom. When fufficiently dry, all the four canvaffes are to be unnailed from the board, and the edges turned up the reverfe way, and nailed to a proper ftretching frame. This is done by unnailing from the board a part on each fide at a time, and immediately nailing it to the ftretching frame, fo as never to leave the canvas to crack or partially ftretch, which would damage the picture. In this manner, by degrees, the cloths are entirely detached from the board, and firmly fixed on the ftretching frame. The fuperfluous canvas, left larger than the frame, may then be cut off, and the wedges put in the frame, and moderately tightened up. There remains then only to clear the furface of the painting from the fecuring canvafs; which is done by repeatedly wafhing the furface

with

with a sponge and moderately warm water. In doing this, no violence or force must be used; and, by frequent and gentle washings, the paste will all be worked out with the sponge. The edges of the outer canvas are then to be cut round, and stripped off: the other, next the surface of the picture, is to be served in like manner; which done, nothing remains but to take the paste clean off, and repair any defects: the picture will then be as strong as if painted on the canvas.

"For taking pictures off walls, without taking the walls down, or cutting away more thereof than the plastering, the following process is proposed:

"The surface of the picture is to be first secured, in the manner before described; but instead of the plain board, a bearer should be prepared with a convex surface, composed of ribs, boarded over, so as to form part of a cylinder, of not less than five feet radius, and as long as the height of the picture. This bearer being prepared, in order to apply it, a floor or platform should be erected, and placed horizontally, with its surface level, and its edge immediately in contact with the bottom of the picture meant to be transferred. The use of this platform is for the above described bearer to rest and move upon; which bearer should be set on its end, with one edge in contact with the wall, at one side of the picture; consequently the other edge will be at some distance from the wall, according to the size of the picture and convexity of the bearer. Being thus placed, the superfluous edge of the securing-canvas should be turned over, and nailed to that edge of the bearer that is next the wall: This done, the operation of cutting away the plastering should be begun; which may be done with the corner and end of a short saw; sawing between the brick-work and plastering, and leaving the thickness, or part of the thickness, of the plastering on the painting fastened to the bearer. When this edge of the picture is freed, the whole height, for nine or ten inches under the edge of the bearer that is furthest from the wall, must then be gently forced nearer; consequently the other edge, together with the painting and plaster that is freed, will leave the wall, and give an opportunity of introducing the saw behind, and cutting away the same to a certain distance farther under; and, by repeating this, the whole of the picture will at length be freed, and left on the bearer. Each time the bearer is removed, and, as it were, rolled on the vertical surface of the wall, care must be taken to turn and nail the securing-canvas on the top and bottom edges of the bearer, so as to secure the freed plastering and picture from moving about; and, lastly, before the bearer and plastering be moved, to nail the other edge of the picture in the same way, which will secure the whole to the bearer. This done, the picture and bearer are at liberty to be moved to a proper place, in order to be freed from the remaining plaster. The edges may then be unnailed; the painting and canvas slipped from this bearer on to a plain board; and the new canvas may be then put on; which is to remain till dry, as in other cases.

"It may appear, that the bending of the canvas and plastering to the convex bearer will crack the plaster, and damage the painting; but, from experience (says Mr Salmon) I have observed, that, to a curve of such or even less radius, plastering will bend, without any visible crack, even on the exterior part thereof; and that part next the bearer, not having occasion, in bending, to extend its parts, will consequently be much less liable to be disturbed by such bending."

In clearing the wood from the paintings, our author never made use of aquatortis, or any other liquid; the use of which he conceives would be very tedious, and attended with danger, lest it should get through the paint, and wet or damp the paste by which the securing canvass is fixed. In working off the wood, he generally made use of such planes as by the joiners are called the *levelled rabbit plane*, and *small rounds*. By the corners of the former, and proper handling of the latter, the wood is cleared off without force or violence: even the smallest particles may, in general, be got off; although in some paintings, and in particular parts of others, he has met with places on which he thought it best to leave some particles, or fine splinters, of wood, but nothing more. Rasps, and sometimes a fine chisel, are useful, to clear off such parts as may be in hollow places, or where particles of wood are left, as above. The time required will be various, according to the manner in which the painting was originally done; some being painted on boards previously prepared with a water colour; others immediately painted with oil on the wood. This last sort is by much the most difficult; the other is more easy, as the previous preparation prevents the wood from imbibing the oil, and consequently admits it to be more easily separated.

PALILICUM, the same as Aldebaran, a fixed star of the first magnitude, in the eye of the bull, or sign Taurus.

PALLIFICATION, or PILING, in architecture, denotes the piling of the ground-work, or the strengthening it with piles, or timber driven into the ground; which is practised when buildings are erected upon a moist or marshy soil.

PALM, an ancient long measure, taken from the extent of the hand. See PALMUS, *Encycl.*

PALMÆ, palms. See *Encyclopædia*. The subject is introduced here to notice a kind of palm, the product of North America, of which we have the following account by Dr Barton.

"There grows upon the river Mobile a species of palm, which is but little known to naturalists, but which promises to be an important article of food to man. It has no stalk or stem above ground. The leaves spread regularly all round, and when fully expanded are flabelliform. In the centre of these leaves is produced the receptacle of the fruit, which is of the form and size of a common sugar-loaf. This receptacle consists of a vast number of drupes, or berries, of the size and shape of common plums: each is covered with a fibrous, farinaceous, pulpy coating, of considerable thickness. This substance is said to resemble manna in texture, colour, and taste; or, perhaps, it still more resembles moist brown sugar, with particles of loaf sugar mixed with it. It is a most delicious and nourishing food, and is diligently sought after in the places where it grows. Upon first tasting it, it is somewhat bitter and pungent.

PANORAMA, a word derived from παν and ὁραω; and therefore employed of late to denote a painting, whether in oil or water colours, which represents an entire view of any country, city, or other natural objects, as they appear to a person standing in any situation, and turning quite round. To produce this effect, the

Plate CVIII

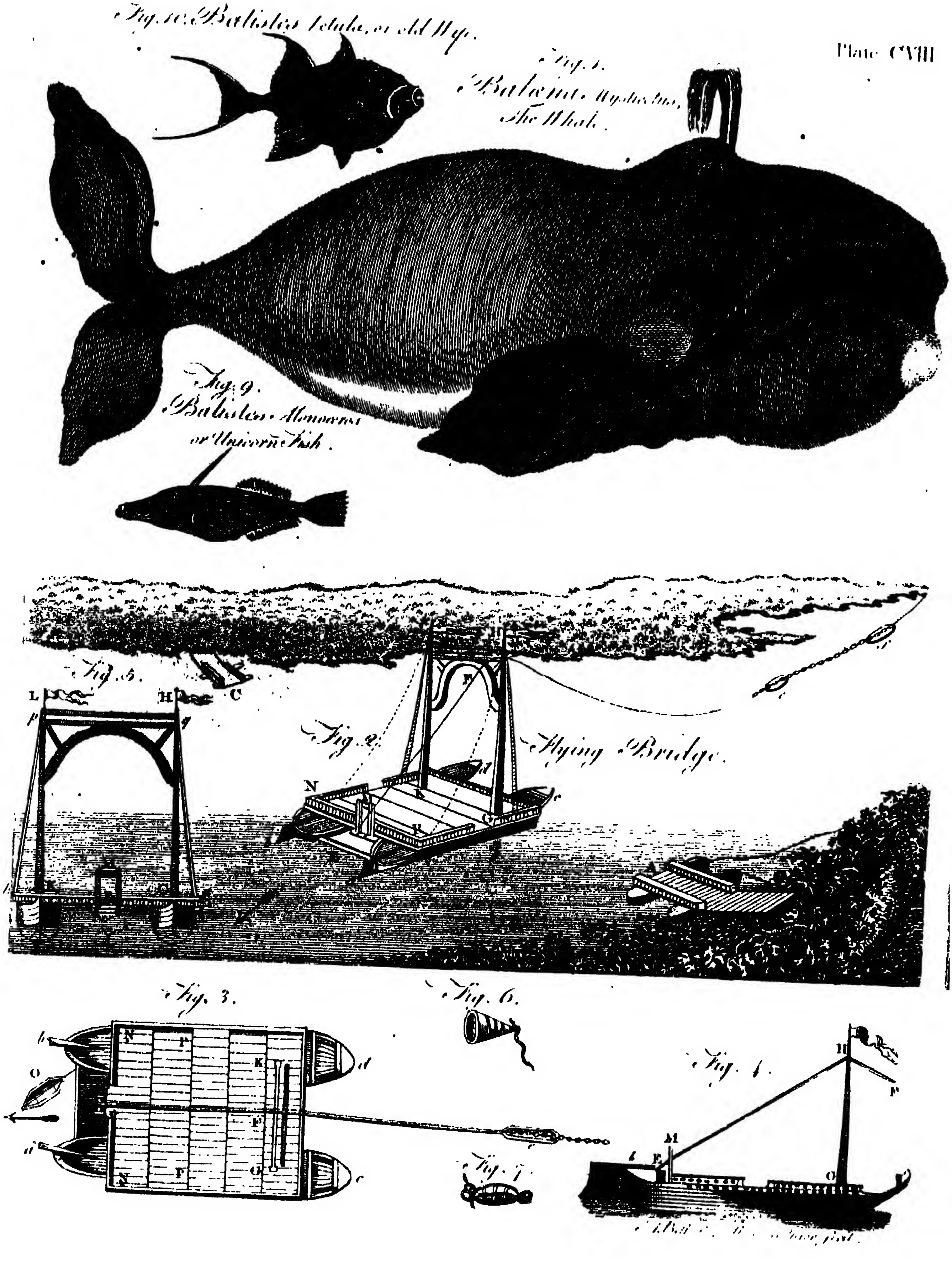
Fig. 10. Balistes Vetula, or old Wife.
Fig. 8.
Balæna Mysticetus,
The Whale.
Fig. 9.
Balistes Monoceros
or Unicorn Fish.
Fig. 5.
L
H
C
p
q
Fig. 2.
Flying Bridge.
N
Fig. 3.
Fig. 6.
Fig. 4.
H
F
M
G
Fig. 7.

Panorama, Paper.

the painter or drawer must fix his station, and delineate correctly and connectedly every object which presents itself to his view as he turns round, concluding his drawing by a connection with where he began. He must observe the lights and shadows, how they fall, and perfect his piece to the best of his abilities. There must be a circular building or framing erected, on which this drawing or painting may be performed; or the same may be done on canvas, or other materials, and fixed or suspended on the same building or framing, to answer the purpose complete It must be lighted entirely from the top, either by a glazed dome, or otherwise as the artist may think proper. There must be an inclosure within the said circular building or framing, which shall prevent an observer going too near the drawing or painting, so as it may, from all parts it can be viewed, have its proper effect. This inclosure may represent a room, or platform, or any other situation, and may be of any form thought most convenient; but the circular form is particularly recommended. Of whatever extent this inside inclosure may be, there must be over it (supported from the bottom, or suspended from the top) a shade or roof; which, in all directions, should project so far beyond this inclosure, as to prevent an observer from seeing above the drawing or painting when looking up; and there must be without this inclosure another interception, to represent a wall, paling, or other interception, as the natural objects represented, or fancy, may direct, so as effectually to prevent the observer from seeing below the bottom of the drawing or painting; by means of which interception, nothing can be seen on the outer circle but the drawing or painting intended to represent nature. The entrance to the inner inclosure must be from below, a proper building or framing being erected for that purpose, so that no door or other interruption may disturb the circle on which the view is to be represented. And there should be, below the painting or drawing, proper ventilators fixed, so as to render a current circulation of air through the whole; and the inner inclosure may be elevated, at the will of an artist, so as to make observers, on whatever situation he may wish they should imagine themselves, feel as if really on the very spot.

PAPER is an article of such importance, and at present * of so enormous a price, that no improvement in its manufacture should pass unnoticed in a work of this nature. The discovery made in France by M. Bertholet of the efficacy of oxy-muriatic acid in expediting the process of BLEACHING (see that article in this *Suppl.*), has contributed essentially to facilitate the manufactures, not only of cotton and linen cloths, but also of paper, of which it has even increased the materials. Formerly writing paper could be made of *unprinted* linen alone; but by means of the process of M. Bertholet even printed linen may be made into the finest and whitest paper. In the year 1795 a patent was granted to Mr Elias Carpenter of Bermondsay, Surrey, for a method of bleaching paper of such materials in the *water-leaf* or *sheet*, and sizing it without drying.

* 1800.

In the preparation of the pulp, the coarser rags are to be macerated for two or three days in a caustic alkaline ley, and wrought into sheets of paper in the usual way; a strong wooden box or trough is then to be procured, of a size proportioned to that of the paper, lined on the inside with white paint, and furnished with several stages of cross bars of glass: the bottom of the box is to be covered with a stratum about one inch deep of caustic ley, and the paper laid by quarter reams, or less, across the glass bar. A hole must be made in the box to admit the beak of an earthen ware retort, into which must be put manganese and sea salt, in powder, sulphuric acid, and an equal quantity of water impregnated with the steams of burning sulphur (sulphureous acid). The cover of the box is to be made air-tight by luting or slips of paper dipped in paste. The apparatus being thus prepared, the belly of the retort is to be plunged in water, kept boiling, and in a short time the oxy muriatic gas will be driven into the box, will penetrate the paper, and render it of a dazzling whiteness, while the alkaline ley at the bottom will, by gradually absorbing it, prevent its becoming so concentrated as to destroy or injure the texture of the paper. From three to four pounds of sulphuric acid will suffice for one hundred weight of paper, and the operation will be completed in about eight hours. The sheets as they are taken out of the box are to be sized with the following mixture:

To 1 cwt of clippings of skin add 14 lb. of alum, 7 of calcined vitriol, and 1 lb. of gum arabic, with a sufficient quantity of water to size 50 reams of fools cap.

The same method will serve equally well to clean engravings or printing; for though the oxy-muriatic acid discharges all stains, dirt, &c yet it is incapable of acting on printers ink.

This, however, is not the only improvement in the manufacture of paper derived from modern chemistry. In Crell's *Chemical Annals* for the year 1797, we have an account of some curious experiments made by M L. Brugnatelli, with the view of rendering

PAPER incombustible, and the writing on it, of course, indestructible by fire. Of all the substances which he tried, he found the liquor of flints the proper to secure paper from destruction by fire. He dipped a sheet of paper several times in the above liquor fresh made, or daubed it several times over the whole paper with a hair brush, and dried it in the sun or in an oven. Paper prepared in this manner lost some of its softness, became a little rougher than before, and acquired a lixivious caustic taste In other respects it was not different from common white paper When this paper was laid upon glowing coals, it did not burn like common paper, but became red, and was converted to a coal, which however did not fall into ashes like the coal of common paper, so that it might therefore be considered as petrified paper. This coal, however, is exceedingly friable; for when it is taken between the fingers, or pressed together in any manner whatever, it drops to pieces. Still the discovery must be a valuable one, if there be any kind of ink of such a nature as that the characters written with it continue visible on this coal. Such an ink M. Brugnatelli made by combining dissolved nitrite of zinc with common ink; and found, that the colour of this mixture, though it appeared somewhat pale on common paper, became so dark on prepared paper, that words written with it appeared more conspicuous than words written with common ink. When the paper was burnt, or reduced to a coal, those characters were so visible, in a clear *white* colour on a *dark* ground, that they could be read with as much ease as characters written with the best ink on white

white paper. If the ingenious author succeed in his attempts to discover a method of rendering his prepared paper less friable when burnt, his discovery will be one of the most important of the present age.

PARABOLIC CONOID, is a solid generated by the rotation of a parabola about its axis. This solid is equal to half its circumscribed cylinder; and therefore if the base be multiplied by the height, half the product will be the solid content.

Parabolic Pyramidoid, is a solid figure, thus named by Dr Wallis from its genesis or formation, which is thus: Let all the squares of the ordinates of a parabola be conceived to be so placed, that the axis shall pass perpendicularly through all their centres; then the aggregate of all these planes will form the parabolic pyramidoid. This figure is equal to half its circumscribed parallelopipedon. And therefore the solid content is found by multiplying the base by the altitude, and taking half the product; or the one of these by half the other.

Parabolic Space, is the space or area included by the curve line and base or double ordinate of the parabola.

Parabolic Spindle, is a solid figure conceived to be formed by the rotation of a parabola about its base or double ordinate.

Parabolic Spiral, is a curve arising from the supposition that the common or Apollonian parabola is bent or twisted till the axis come into the periphery of a circle, the ordinates still retaining their places and perpendicular positions with respect to the circle, all these lines still remaining in the same place. This figure is sometimes called the *Helicoid parabola*.

PARABOLOIDES, parabolas of the higher orders. The equation for all curves of this kind being $a^{m-n} x^n = y^m$, the proportion of the area of any one to the complement of it to the circumscribing parallelogram, will be as *m* to *n*.

PARACENTRIC MOTION, denotes the space by which a revolving planet approaches nearer to, or recedes farther from, the sun, or centre of attraction.

Paracentric Solicitation of Gravity, is the same as the vis centripeta.

PARACHUTE, a kind of large and strong umbrella, contrived to break a person's fall from an air-balloon, should any accident happen to the balloon at a high elevation. This contrivance was first thought of by Blanchard, who at different times, by means of the parachute, let fall from his balloon dogs and other animals. He ventured even to descend in this manner himself; but, whether from the bad construction of his parachute, or from falling among trees, he had the misfortune to break one of his legs. Citizen Garnerin, as he chooses to be called, was more successful. On the 21st of October 1797, he ascended from the garden de Mausseux at half past five in the evening; between the balloon and the car, in which he sat, was placed the parachute, half opened, and forming a kind of tent over the aërial traveller; and when the whole apparatus was at a considerable height, he separated the parachute and car from the balloon. The parachute unfolding itself, was, by his weight and that of the car, drawn of course towards the earth. Its fall was at first slow and vertical; but soon afterwards it exhibited a kind of balancing or vibration, and a rotation gradually increasing, which might be compared with that of a leaf falling from a tree. The aëronaut, however, reached the ground unhurt.

This parachute was of cloth, and its diameter, when unfolded, about twenty-five feet. To use such instruments with success, it is necessary that the car be suspended at a considerable distance from the parachute, so as that the centre of gravity of the whole shall be vertically below the centre of resistance made by the air to the descent of the parachute; for if the car be otherwise placed, it is evident that the parachute will incline to one side, descend obliquely, oscillate, and the smallest irregularity in its figure will cause it to turn round its vertical axis.

PARAGUATAN, a kind of wood which grows in Guiana, and promises to be of great utility as a dye stuff. We have seen no botanical description of the tree; but from the report made to the Council of Trade and Mines, by D. Dominique Garcia Fernandez, inspector of coinage, we learn that its bark, boiled in water, affords a coloured extract which resists the agency of acids for a longer time than brazil or logwood; that the colour may be revived by means of alkalies, after it has been destroyed by combination with acids; that vinegar, lemon juice, and tartar, render this colour more brilliant, while they entirely destroy the colours of brazil and logwood; that the fecula of the bark of paraguatan fixes and attaches itself to wool, cotton, and silk; and that the colour is brighter on silk than on wool, and brighter on wool than on cotton. The same fecula dried is afterwards soluble in alcohol, to which it communicates a tinge similar to that afforded by cochineal; but it must be confessed, that the colour obtained from paraguatan has not the force of that of cochineal, though it is superior to those of madder, brazil wood, and logwood. From these facts D. Fernandez considers the paraguatan as one of the most valuable productions which America furnishes to Spain.

PARALLAX (see *Encycl.*) is used, not only in astronomy, but also in levelling, for the angle contained between the line of true level, and that of apparent level. And, in other branches of science, for the difference between the true and apparent places.

PARALLEL RULER, is a mathematical instrument, consisting of two equal rulers, either of wood or metal, connected together by two slender cross bars or blades of equal length, moveable about the points of junction with the rulers. There are other forms of the instrument; some, for instance, having the two blades crossing in the middle, and fixed only at one end of them, the other two ends sliding in grooves along the two rulers, &c.

The use of this instrument is obvious. For the edge of one of the rulers being applied to any line, the other opened to any extent will be always parallel to the former; and consequently any parallels to this may be drawn by the edge of the ruler, opened to any extent.

PARALLELS, or PLACES OF ARMS, in a siege, are deep trenches, 15 or 18 feet wide, joining the several attacks together; and serving to place the guard of the trenches in, to be at hand to support the workmen when attacked. There are usually three in an attack: the first is about 600 yards from the covert-way, the second between 3 and 400, and the third near or on the

Parallelism — the glacis. It is said they were first invented or used by Vauban.

Paramaribo — PARALLELISM OF THE EARTH'S AXIS, is that invariable situation of the axis, in the progress of the earth thro' the annual orbit, by which it always keeps parallel to itself; so that if a line be drawn parallel to its axis, while in any one position, the axis, in all other positions or parts of the orbit, will always be parallel to the same line.

PARAMETER, a certain constant right line in each of the three conic sections; otherwise called also *latus rectum*.

PARAMARIBO, the capital of the Dutch settlement at Surinam, is situated on the right side of the beautiful river Surinam, at about 16 or 18 miles distance from its mouth. It is built upon a kind of gravelly rock, which is level with the rest of the country, in the form of an oblong square; its length is about a mile and a half, and its breadth about half as much. All the streets, which are perfectly straight, are lined with orange, shaddock, tamarind, and lemon trees, which appear in everlasting bloom; while, at the same time, their branches are weighed down with the richest clusters of odoriferous fruit. Neither stone nor brick is made use of here for pavement; the whole being one continued gravel, not inferior to the finest garden walks in England, and strewed on the surface with sea shells. The houses, which are mostly of two and some of three stories high, are all built of fine timber, a very few excepted; most of the foundations are of brick, and they are roofed with thin split boards, called *shingles*, instead of slates or tiles. Windows are very seldom seen in this country, glass being inconvenient on account of the heat; instead of which they use gauze frames: some have only the shutters, which are kept open from six o'clock in the morning until six at night. As for chimneys, there are none in the colony; no fires being lighted except in the kitchens, which are always built at some distance from the dwelling house, where the victuals are dressed upon the floor, and the smoke let out by a hole made in the roof: these timber houses are, however, very dear in Surinam, one of them having cost above L. 15,000 sterling. There is no spring water to be met with in Paramaribo; most houses have wells dug in the rock, which afford but a brackish kind of beverage, only used for the negroes, cattle, &c. and the Europeans have reservoirs or cisterns, in which they preserve rain-water for their own consumption; those of nicer taste let it first drop through a filtering-stone into large jars or earthen pots, made by the native Indians on purpose, which they barter at Paramaribo for other commodities. The inhabitants of this country, of every denomination, sleep in hammocks, the negro slaves excepted, who mostly lie on the ground: the hammocks used by those in superior stations are made of cotton, ornamented with rich fringe; these are also made by the Indians, and sometimes worth above twenty guineas; neither bedding nor covering is necessary, except an awning to keep off the musquitoes. Some people indeed lie on bedsteads; in that case they are surrounded, instead of curtains, with gauze pavilions, which admit the air freely, and at the same time keep off the smallest insect. The houses in general at Paramaribo are elegantly furnished with paintings, gilding, crystal chandeliers, china jars, &c.; the rooms are never papered or plastered, but beautifully wainscotted with cedar, and Brazil, and mahogany wood.

The number of buildings in Paramaribo is computed at about 1400, of which the principal is the governor's palace, whence there is a private passage through the garden which communicates with Fort Zelandia. This house, and that of the commandant, which has lately been burnt, were the only brick buildings in the colony. The town-hall is an elegant new building, and covered with tiles; here the different courts are held, and underneath are the prisons for European delinquents, the military excepted, who are confined in the citadel of Fort Zelandia. The Protestant church, where divine worship is performed both in French and Low Dutch, has a small spire with a clock; besides which there is a Lutheran chapel, and two elegant Jewish synagogues, one German the other Portuguese. Here is also a large hospital for the garrison, and this mansion is never empty. The military stores are kept in the fortress, where the society soldiers are also lodged in barracks, with proper apartments for some officers. The town of Paramaribo has a noble road for shipping, the river before the town being above a mile in breadth, and containing sometimes above 100 vessels of burden, moored within a pistol-shot of the shore. Before Holland became a province of France, and thereby lost her trade, there were seldom fewer than 80 ships at Paramaribo, loading coffee, sugar, cocao, cotton, and indigo, for the mother country, including also the Guinea-men that bring slaves from Africa, and the North American and Leeward Island vessels, which bring flour, beef, pork, spirits, herrings, and mackarel salted, spermaceti candles, horses, and lumber; for which they receive chiefly molasses to be distilled into rum. This town is not fortified, but is bounded by the river on the south east; by a large savannah on the west; by an impenetrable wood on the north east; and is protected by Fort Zelandia on the east. This citadel is only separated from the town by a large esplanade, where the troops parade occasionally. The fort is a regular pentagon, with one gate fronting Paramaribo, and two bastions which command the river; it is very small but strong, being made of rock or hewn stone, surrounded by a broad fosse well supplied with water, besides some outworks. On the east side, fronting the river, is a battery of 21 pieces of cannon. On one of the bastions is a bell, which is struck with a hammer by the centinel, who is directed by an hour-glass. On the other is planted a large ensign-staff, upon which a flag is hoisted upon the approach of ships of war, or on public rejoicing days. The walls are six feet thick, with embrasures, but no parapet.

Paramaribo is a very lively place, the streets being generally crowded with planters, sailors, soldiers, Jews, Indians, and Negroes, while the river is covered with canoes, barges, &c. constantly passing and repassing like the wherries on the Thames, often accompanied with bands of music; the shipping also in the road adorned with their different flags, guns firing, &c. not to mention the many groupes of boys and girls playing in the water, altogether form a pleasing appearance; and such gaiety and variety of objects serve, in some measure, to compensate for the many inconveniences of the climate. Their carriages and dress are truly magnificent; silk, embroidery, Genoa velvets, diamonds, gold and silver

Paramaribo, Paris. Paris.

lace, being daily worn, and even the masters of trading ships appear with buttons and buckles of solid gold. They are equally expensive at their tables, where every thing that can be called delicate is produced at any price, and served up in plate and china of the newest fashion, and most exquisite workmanship. But nothing displays the luxury of the inhabitants of Surinam more than the number of slaves by whom they are attended, often twenty or thirty in one family. White servants are seldom to be met with in this colony.

The current money are stamped cards of different value, from five shillings to fifty pounds: gold and silver is so scarce, that the exchange premium for specie is often above 10 *per cent.* A base Dantzic coin called a *bit*, value something less than sixpence, is also current in Surinam. English and Portuguese coin are sometimes met with, but mostly used as ornaments by the Mulatto, Samboe, Quaderoon, and Negro girls. The Negro slaves never receive any paper money; for as they cannot read, they do not understand its value; besides, in their hands it would be liable to many accidents, from fire or children, and particularly from the rats, when it becomes a little greasy.

This town is well supplied with provisions, *viz.* butchers meat, fowls, fish, and venison. Vegetables in particular the country abounds with; besides the luxuries peculiar to this climate, they import whatever Europe, Africa, and Asia can afford. Provisions, however, are excessively dear in general, especially those imported, which are mostly sold by the Jews and masters of ships. The first enjoy extraordinary privileges in this colony; the latter erect temporary warehouses for the purpose of trade, during the time their ships are loading with the productions of the climate. Wheat flour is sold from four-pence to one shilling per pound; butter, two shillings; butcher's meat never under one shilling, and often at one shilling and sixpence; ducks and fowls from three to four shillings a couple. A single turkey has sometimes cost one guinea and a half; eggs are sold at the rate of five, and European potatoes twelve, for sixpence. Wine three shillings a bottle. Jamaica rum a crown a gallon. Fish and vegetables are cheap, and fruit almost for nothing.

PARIS (Francis), a man more famous after his death than during his life, by the miracles which were said to be performed at his tomb. He is generally known by the name of Abbé Paris; and his pretended miracles, with others of like manufacture, have furnished deistical writers, and Mr Hume in particular, with a kind of argument against the reality of the miracles of which we have an account in the Gospel. It is merely that we may state his pretensions fairly, that we have introduced him to the notice of our readers; for in every other respect he is wholly unworthy of their regard. He was the son of a counsellor in Parliament, and had the prospect, if he had chosen it, of succeeding to his father's appointment; but he chose rather to become an ecclesiastic, and he became a very zealous one. He gave up all his possessions to his brother, refused preferment intended for him by the cardinal de Noailles, devoted himself entirely to retirement, and made stockings for his own support, and for the assistance of the poor. He died, perhaps in consequence of his rigorous mode of life, May 1. 1727, at the age of only 37. His brother raised a monument to him in the small churchyard of St Medard, to which the poor and the pious soon began to flock; and after a time it was reported, that, in consequence of their prayers at that tomb, some sick persons had received cures. As Paris had been a rigorous Jansenist, this was a fine opportunity for that sect to gain credit to their cause; the miracles were therefore multiplied, and a variety of persons affected the most singular convulsions.

The minds of the people becoming inflamed by these extravagancies, the court found it necessary to shut up the churchyard, which was done on the 27th of January 1732. On this occasion, some profane wit wrote upon the wall of the place,

> DE PAR LE ROY, defense a Dieu,
> De faire miracles en ce lieu.

The convulsions were continued, for a little while, in private houses, but by degrees the matter subsided, and the Abbé Paris was forgotten.

The distinction between miracles exhibited to serve a party, and attested only by those who are zealous in its support, and miracles performed in the sight of unbelievers, who, in spite of their deep-rooted prejudices, were converted by them, is too striking to be overlooked by any, but those who are desirous of drawing a false and impious parallel; yet has Mr Hume dared to represent the miracles performed at the tomb of this saint as outvying in number, nature, and evidence, the miracles of Christ and his apostles—with what truth, the following observations will shew:

1st, It was often objected by the enemies of the saint, and the objection was never confuted by his friends, that the *prostrations* at his sepulchre, like animal magnetism more lately, *produced* more diseases than they *cured*. Such, surely, was not the nature of our Saviour's miracles.

2dly, Though the crowds of sick and infirm persons who flocked to the tomb for relief were, by all accounts, innumerable; yet all the cures, of which the zealous historian of the Miracles could procure vouchers, amounted only to NINE! Now, were thousands, and ten thousands of diseased persons to apply to some circumforaneous quack, in full assurance of his extraordinary abilities and skill in physic, could it surprise any person, if the distempers of *eight* or *nine* of them should take a favourable turn while they were under a course of his useless medicines?

3dly, We do not read that of those nine who were cured by the dead Abbé, the greater part were Jesuits and enemies to the Jansenists; whereas the greater part of our Saviour's miracles were performed upon unconverted Jews, and one of them upon the servant of the high priest, who was thirsting for his blood.

4thly, The cures reported to have been performed at the grave of Paris were all such as might have been accomplished by natural means. Thus, a Spaniard who had lost one eye, and was distressed with an inflammation in the other, had the inflamed eye gradually cured, but not the lost eye restored. Another person having pricked his eye with an awl, lost the sight of it in consequence of the aqueous humour dropping out; but his sight was restored *whilst* he was paying his devotions to the Abbé—and so it would have been while he was cursing the Abbé, had he continued his execrations for a sufficient length of time.

5thly,

Paris, Parkhurst.

5*thly*, None of the cures said to have been performed were *instantaneous*. *All* the worshippers at the tomb persisted for *days*, several of them for *weeks*, and some for *months*, daily imploring the intercession of the Abbé *before* they received relief from their complaints.

6*thly*, Most of the devotees had been using *medicines* before they applied to the saint, and continued to use them *during the whole time* of their application; whilst it is confessed that the distempers of others had *abated* before they determined to solicit his help.

7*thly*, Some of the cures attested were *incomplete*, and only of a temporary duration. Thus, the Spaniard was relieved only from the most inconsiderable part of his complaint, and that too but for a very short period; for soon after his return home he relapsed into his former malady, as was fully attested by certificates and letters from Madrid. All this has been completely proved by the Archbishop of Sens; who in his *Pastoral Instruction*, published at the time the miracles were making a noise, has,

8*thly*, Clearly detected the deceit and little artifices by which those pretended miracles were so long supported. To that work we refer our readers; requesting them, after they have read it, to compare the evidence for the miracles of Paris with the evidence which in the article MIRACLE (*Encycl.*) we have stated for the reality of the Gospel miracles, and to judge for themselves with the impartiality of philosophers.

Paris wrote a few very indifferent books of annotations on the Epistles to the Romans, to the Galatians, and the Hebrews; but few have ever read them, nor would they have rescued the author from oblivion, without the aid of his lying wonders.

PARKHURST (the Rev. John), was the second son of John Parkhurst, Esq; of Catesby in Northamptonshire. His mother was Ricarda Dormer, daughter of Judge Dormer. He was born in June 1728, was educated at the school of Rugby in Warwickshire, and was afterwards of Clare-hall, Cambridge; B. A. 1748, M. A. 1752; and many years fellow of his college.

Being a younger brother, he was intended for the church; but not long after his entering into holy orders his elder brother died. This event made him the heir of a very considerable estate; though, as his father was still living, it was some time before he came into the full possession of it; and when he did come into the possession of it, the acquisition of fortune produced no change on his manners or his pursuits. He continued to cultivate the studies becoming a clergyman; and from his family connections, as well as from his learning and piety, he certainly had a good right to look forward to preferment in his profession; but betaking himself to retirement, and to a life of close and intense study, he sought for no preferment; and, according to the author of the biographical sketch of him published in the Gentleman's Magazine, he lived not in an age when merit was urged forward. Yet, in the capacity of a curate, but without any salary, he long did the duty, with exemplary diligence and zeal, in his own chapel at Catesby, which, after the demolition of the church of the nunnery there, served as a parish-church, of which also he was the patron.

When, several years after, it fell to his lot to exercise the right of presentation, he was so unfashionable as to consider church-patronage as a trust rather than a property; and, accordingly, resisting the influence of interest, favour, and affection, presented to the vicarage of Epsom, in Surrey, the Rev. Jonathan Boucher, who still holds it. This gentleman was then known to him only by character; but having distinguished himself in America, during the revolution, for his loyalty, and by teaching the unsophisticated doctrines of the church of England to a set of rebellious schismatics at the peril of his life, Mr Parkhurst thought, and justly thought, that he could not present to the vacant living a man who had given better proofs of his having a due sense of the duties of his office.

In the year 1754, Mr Parkhurst married Susanna Myster, daughter, and, we believe, heiress of John Myster, Esq; of Epsom. It was thus that he became patron of the living which he bestowed on Mr Boucher. This lady died in 1759, leaving him a daughter and two sons; both the sons are now dead. In the year 1761, he married again Millicent Northey, daughter of Thomas Northey, Esq; by whom he had one daughter, now married to the Rev. Joseph Thomas.

In the year 1753, he began his career of authorship, by publishing, in 8vo, "A friendly Address to the Rev. Mr John Wesley, in relation to a principal Doctrine maintained by him and his Assistants." This work we have not seen; but though we have no doubt of its value, we may safely say that it was of very little importance, when compared with his next publication, which was "An Hebrew and English Lexicon, without Points; to which is added, a methodical Hebrew Grammar, without Points, adapted to the use of Learners, 1762," 4to. To attempt a vindication of all the etymological and philosophical disquisitions which are scattered through this dictionary, would be very fruitless; but it is not perhaps too much to say, that we have nothing of the kind equal to it in the English language. He continued, however, to correct and improve it; and in 1778 another edition of it came out much enlarged, and a third in 1792.

His philological studies were not confined to the Hebrew language; for he published a Greek and English Lexicon to the New Testament; to which is prefixed, a plain and easy Greek Grammar, 1769, 4to; a second edition, 1794: and at his death there was in the press a new edition of both these lexicons, in a large 8vo, with his last corrections; for he continued to revise, correct, add to, and improve, these works, till within a few weeks of his death. As, from their nature, there cannot be supposed to be any thing in dictionaries that is particularly attractive and alluring, this continued increasing demand for these two seems to be a sufficient proof of their merit.

He published, "The Divinity and Pre-existence of our Lord and Saviour Jesus Christ, demonstrated from Scripture; in Answer to the first Section of Dr Priestley's Introduction to the History of early Opinions concerning Jesus Christ; together with Strictures on some other Parts of the Work, and a Postscript relating to a late Publication of Mr Gilbert Wakefield, 1787," 8vo. This work was very generally regarded as completely performing all that its title page promised; and accordingly the whole edition was soon sold off. The brief, evasive, and very unsatisfactory notice taken of this able pamphlet by Dr Priestley, in "A

Parkhurst. Letter to Dr Horne," &c. shewed only that he was unable to answer it.

Mr Parkhurst was a man of very extraordinary independency of mind and firmness of principle. In early life, along with many other men of distinguished learning, it was also objected to him, that he was an Hutchinsonian; and on this account alone, in common with them, it has been said that he was neglected and shunned.

There is not, in the history of the times, says the biographer already quoted, a circumstance more difficult to be accounted for than the unmerited, but increasing, discountenance shewn to those persons to whom Hutchinsonianism was then objected. Methodists, Papists, and sectaries of any and of every name, all stood a better chance of being noticed and esteemed than Hutchinsonians. Had it even been proved that the few peculiar tenets by which they were distinguished from other Christians were erroneous, the opposition they experienced might have been deemed *hard measure*, because even their opponents allowed their principles to be inoffensive, and themselves to be learned.

Is this a fair state of the case? We think not. The early Hutchinsonians had imbibed all the peculiar notions of their master, and maintained them with a degree of acrimony which would have disgraced any cause. Being in general very little acquainted with the higher mathematics, as Mr Hutchinson himself seems likewise to have been, they censured dogmatically works which, without that knowledge, they could not fully understand; whilst they maintained, with equal dogmatism, as matters of fact, hypotheses, which a moderate share of mathematical science would have shewn them to be impossible. Had they stopt here, no harm would have been done; they might have enjoyed their favourite notions in peace: but unfortunately they accused of Atheism, Deism, or Socinianism, all who thought not exactly as *they* thought, both in natural philosophy and in theology. Because Newton and Clarke had demonstrated that the motions of the planets cannot be the effect of the impulsion of any material fluid, Hutchinson, with some of his followers, affirmed, that these two illustrious men had entered into a serious design to overturn the Christian religion, and establish in England the worship of the Heathen Jupiter, or the Stoical *anima mundi*. Because the Bishops Pearson, Bull, and others, who had uniformly been considered as the ablest defenders of the Catholic faith, thought not exactly as Hutchinson thought of the filiation of the Son of God, they were condemned by the pupils of his school as *Arians*, or at least *Semi-arians*; and the writer of this sketch has heard a living Hutchinsonian pronounce the same censure, and for the same reason, on the present illustrious Bishop of Rochester, and the no less illustrious Whitaker.

That men, who thus condemned all that before them had been deemed great and good in physical science and Christian theology, should meet with some discountenance while they continued of such a spirit, needs not surely excite much wonder; but that the discountenance is increasing, we believe not to be true. The Hutchinsonians, as soon as they became less violent against those who differed from them, had their share of preferment, in proportion to their number, with others; and we doubt not they will continue to have it, while they allow that a man may be no heretic, though he believe not Mr Hutchinson to have been infallible. The late excellent Bishop Horne was an avowed Hutchinsonian, though not an outrageous one like Julius Bate; and we have been told, and have reason to believe, that the Bishop of St Asaph is likewise a moderate favourer of the same system. There may be others on the episcopal bench; but perhaps two out of twenty-six is the full proportion of Hutchinsonian divines of eminence in England. It is true that Mr Parkhurst was a man of great learning and great worth; but before we attribute his want of preferment in the church to his Hutchinsonianism, it is incumbent upon us to say why Mr Whitaker, who is no Hutchinsonian, is still nothing more than the rector of Ruan-Lanyhorne.

Mr Parkhurst, however, was not, if his biographer deserves credit, a thorough-paced Hutchinsonian; for though he continued to read Hutchinson's writings as long as he read at all, he was ever ready to allow, that he was oftentimes a confused and bad writer, and sometimes unbecomingly violent. To have been deterred from reading the works of an author, who, with all his faults, certainly throws out many useful hints, for fear of being thought a Hutchinsonian, would have betrayed a pusillanimity of which Mr Parkhurst was incapable. What he believed he was not afraid to profess; and never professed to believe any thing which he did not very sincerely believe. An earnest lover of truth, he sought it where only it is to be found—in the Scriptures (A). The study of these was at once the business and the pleasure of his life; from his earliest to his latest years, he was an hard student: and had the daily occupations of every 24 hours of his life been portioned out, as it is said those of king Alfred were, into three equal parts, there is reason to believe that a deficiency would rarely have been found in the eight hours allotted to study. What the fruits have been of a life so conducted, few theologians, it is presumed, need to be informed, it being hardly within the scope of a supposition, that any man will now sit down to the study of the Scriptures without availing himself of the assistance to be obtained from his learned labours. These labours ceased at Epsom in Surrey, where this great and good man died, on March the 21st, 1797. Besides the works which we have mentioned, there is in the Gentleman's Magazine, for August 1797, a curious letter of his on the Confusion of Tongues at Babel.

Mr Parkhurst's character may be collected with tolerable accuracy even from this imperfect sketch of his life. His notions of church patronage do him honour; and as a farther instance of the high sense he entertained

(A) This is vague language, which is the source of much useless controversy, and therefore ought to be avoided. by *truth*, in this passage, be meant *religious* truth, we admit the assertion in the only sense in which we think can have been made. If the author means *all* truth, he writes nonsense; for the Scriptures treat not of *geo-'ry* or *algebra*, where truth is certainly to be found; and *we think* that they have a higher object than even *hanics* and *astronomy*.

Parkhurst, Parkinson.

ed of strict justice, and the steady resolution with which he practised it on all occasions, an incident which occurred between him and one of his tenants, within these ten years, may here be mentioned. This man falling behind hand in the payment of his rent, which was L. 500 *per annum*, it was represented to his landlord that it was owing to his being over rented. This being believed to be the case, a new valuation was made; and it was then agreed that, for the future, the rent should not be more than L. 450. Justly inferring, moreover, that if the farm was *then* too dear, it must necessarily have been *always* too dear, unasked, and of his own accord, he immediately struck off L. 50 from the commencement of the lease; and instantly refunded all that he had received more than L. 450 *per annum*.

Mr Parkhurst was in his person rather below the middle size, but remarkably upright, and firm in his gait. He was all his life of a sickly habit: and his leading so remarkably studious and sedentary a life (it having, for many years, been his constant practice to rise at five, and, in winter, to light his own fire) to the very verge of David's limits of the life of man, is a consolatory proof to men of similar habits, how much, under many disadvantages, may still be effected by strict temperance and a careful regimen. He also gave less of his time to the ordinary interruptions of life than is common. In an hospitable, friendly, and pleasant neighbourhood, he visited little; alleging, that such a course of life neither suited his temper, his health, nor his studies. Yet he was of sociable manners; and his conversation always instructive, often delightful: for his stores of knowledge were so large, that he too has often been called a walking library. He belonged to no clubs; he frequented no public places; and there are few men who, towards the close of life, may not, on a retrospect, reflect with shame and sorrow, how much of their precious time has thus been thrown away, or, perhaps, worse than thrown away.

Like many other men of infirm and sickly frames, Mr Parkhurst was also irritable, and quick, warm, and earnest, in his resentments, though never unforgiving. But whether it be or be not a matter of reproach to possess a mind so constituted, it certainly is much to any man's credit to counteract and subdue it by an attention to the injunctions of religion. This Mr Parkhurst effectually did: and few men have passed through a long life more at peace with his neighbours, more respected by men of learning, more beloved by his friends, or more honoured by his family.

PARKINSON (John). Of this ingenious English botanist, one of the first and most industrious cultivators of that science among us, the memorials that remain are very scanty. He was born in 1567, was bred an apothecary, and resided in London. He rose to such reputation in his profession as to be appointed apothecary to King James I.; and, on the publication of his Theatre of Plants, he obtained from the unfortunate successor of that prince the title of *Botanicus Regis primarius*. The time of his death cannot be exactly ascertained; but, as his Herbal was published in 1640, and it appears that he was living at that time, he must have attained his 73d year. *Biog. Dict.*

Parkinson's first publication was, his 1. *Paradisi in Sole Paradisus terrestris*, or, A Garden of all Sorts of Pleasant Flower which our English Ayre will permit to be nursed up with a Kitchen garden of all manner of Herbes, Roots, and Fruits, for Meat or Sause, &c. &c. Collected by John Parkinson apothecary, of London, 1629, folio, 612 pages. In this work the plants are arranged without any exact order: nearly 1000 plants are separately described, of which 780 are figured on 129 tables, which appear to have been cut expressly for this work. Parkinson was, it is conceived, the first English author who separately described and figured the subjects of the flower garden; and this book is therefore a valuable curiosity, as exhibiting a complete view of the extent of the English garden at the beginning of the last century. It may, perhaps, be necessary to inform the reader, that Paradisus in Sole, is meant to express the author's name, *Park in sun*. 2. In 1640 he published his *Theatrum Botanicum*; or Theatre of Plants, or an Herbal of a large extent: containing therein, a more ample and exact History and declaration of the Physical Herbs and Plants than are in other Authors, &c. &c. London, folio, 1745 pages. This work had been the labour of the author's life; and he tells us that, owing to "the disastrous times," and other impediments, the printing of it was long retarded. Dr Pulteney is of opinion, that, allowing for the defects common to the age, Parkinson will appear "more of an original author than Gerard or Johnson, independent of the advantages he might derive from being posterior to them. His theatre was carried on through a long series of years, and he profited by the works of some late authors, which Johnson, though they were equally in his power, had neglected to use. Parkinson's descriptions, in many instances, appear to be new. He is more particular in pointing out the places of growth. Johnson had described about 2850 plants. Parkinson has near 3800. These accumulations rendered the *Theatrum Botanicum* the most copious book on the subject in the English language; and it may be presumed, that it gained equally the approbation of medical people, and of all those who were curious and inquisitive in this kind of knowledge."

Parkinson, Parsons.

PARSONS (James), an excellent physician and polite scholar, was born at Barnstaple, in Devonshire, in March 1705. His father, who was the youngest of nine sons of Colonel Parsons, and nearly related to the baronet of that name, being appointed barrack-master at Bolton in Ireland, removed with his family into that kingdom soon after the birth of his then only son, James, who received at Dublin the early part of his education, and, by the assistance of proper masters, laid a considerable foundation of classical and other useful learning, which enabled him to become tutor to Lord Kingston. Turning his attention to the study of medicine, he went afterwards to Paris, where (to use his own words) "he followed the most eminent professors in the several schools, as Astruc, Dubois, Lemery, and others; attended the anatomical lectures of the most famous [Hunaud and De Cat]; and chemicals at the King's Garden at St Come. He followed the physicians in both hospitals of the Hotel Dieu and La Charité, and the chemical lectures and demonstrations of Lemery and Bouldoc; and in botany Jussieu. Having finished these studies, his professors gave him honourable attestations of his having followed them with dili-

gence

Parsons.

gence and industry, which intitled him to take the degrees of doctor and professor of the art of medicine, in any university in the dominions of France. Intending to return to England, he judged it unnecessary to take degrees in Paris, unless he had resolved to reside there; and as it was more expensive, he therefore went to the university of Rheims, in Champaign, where, by virtue of his attestations, he was immediately admitted to three examinations, as if he had finished his studies in that academy; and there was honoured with his degrees June 11. 1736. In the July following he came to London, and was soon employed by Dr James Douglas to assist him in his anatomical works, where in some time he began to practise. He was elected a member of the Royal Society in 1740; and, after due examination, was admitted a licentiate of the college of physicians April 1. 1751; paying college fees and bond stamps of different denominations to the amount of L. 41 : 2 : 8, subject also to quarterage of L. 2 *per annum*. In 1755 he paid a farther sum of L. 7, which, with the quarterage money already paid, made up the sum of L. 16, in lieu of all future payments." On his arrival in London, by the recommendation of his Paris friends, he was introduced to the acquaintance of Dr Mead, Sir Hans Sloane, and Dr James Douglas. The great anatomist made use of his assistance, not only in his anatomical preparations, but also in his representations of morbid and other appearances; a list of several of which was in the hands of his friend Dr Maty, who had prepared an *eloge* on Dr Parsons, which was never used, but which, by the favour of Mrs Parsons, Mr Nichols has preserved at large. Though Dr Parsons cultivated the several branches of the profession of physic, he was principally employed in the obstetrical line. In 1738, by the interest of his friend Dr Douglas, he was appointed physician to the public infirmary in St Giles's. In 1739 he married Miss Elizabeth Reynolds, by whom he had two sons and a daughter, who all died young. Dr Parsons resided for many years in Red Lion Square, where he frequently enjoyed the company and conversation of Dr Stukely, Bishop Lyttleton, Mr Henry Baker, Dr Knight, and many other of the most distinguished members of the Royal and Antiquarian Societies, and that of Arts, Manufactures, and Commerce; giving weekly an elegant dinner to a large but select party. He enjoyed also the literary correspondence of D'Argenville, Buffon, Le Cat, Beccaria, Amb. Bertrand, Valltravers, Ascanius, Turberville Needham, Dr Garden, and others of the most distinguished rank in science. As a practitioner, he was judicious, careful, honest, and remarkably humane to the poor; as a friend, obliging and communicative; chearful and decent in conversation, severe and strict in his morals, and attentive to fill with propriety all the various duties of life. In 1769, finding his health impaired, he proposed to retire from business and from London; and with that view disposed of a considerable number of his books and fossils, and went to Bristol. But he returned soon after to his old house, and died in it after a week's illness, on the 4th of April, 1770. By his last will, dated in October 1766, he gave his whole property to Mrs Parsons; and in case of her death before him, to Miss Mary Reynolds her only sister, "in recompence for her affectionate attention to him and to his wife, for a long course of years, in sickness and in health." It was his particular request, that he should not be buried till some change should appear in his corpse; a request which occasioned him to be kept unburied 17 days, and even then scarce the slightest alteration was perceivable. He was buried at Hendon, in a vault which he had caused to be built on the ground purchased on the death of his son James, where his tomb had a very commendatory inscription.

Parsons.

It would carry us beyond our usual limits to enter into an enumeration of the many curious articles at various times communicated to the public by Dr Parsons, which may be seen in the Anecdotes of Bowyer. We shall therefore close this article with an extract from Dr Maty's eulogium: "The surprising variety of branches which Dr Parsons embraced, and the several living as well as dead languages he had a knowledge of, qualified him abundantly for the place of assistant secretary for foreign correspondences, which the council of the Royal Society bestowed upon him about the year 1750. He acquitted himself to the utmost of his power of the functions of this place, till a few years before his death, when he resigned in favour of his friend, who now gratefully pays this last tribute to his memory. Dr Parsons joined to his academical honours those which the Royal College of Physicians of London bestowed upon him, by admitting him, after due examination, licentiate, on the first day of April 1751. The diffusive spirit of our friend was only equalled by his desire of information. To both these principles he owed the intimacies which he formed with some of the greatest men of his time. The names of Folkes, Hales, Mead, Stukely, Needham, Baker, Collinson, and Garden, may be mentioned on this occasion, and many more might be added. Weekly meetings were formed, where the earliest intelligence was received and communicated of any discovery both here and abroad; and new trials were made, to bring to the test of experience the reality or usefulness of these discoveries. Here it was that the microscopical animals found in several infusions were first produced; the propagation of several insects by section ascertained; the constancy of Nature amidst these wonderful changes established. His Remains of Japhet, being Historical Enquiries into the Affinity and Origin of the European Languages, are a most laborious performance, tending to prove the antiquity of the first inhabitants of these islands as being originally descended from Gomer and Magog, above 1000 years before Christ, their primitive and still subsisting language, and its affinity with some others. It cannot be denied but that there is much ingenuity, as well as true learning, in this work, which helps conviction, and often supplies the want of it. But we cannot help thinking that our friend's warm feelings now and then mislead his judgment, and that some at least of his conjectures, resting upon partial traditions, and poetical scraps of Irish filids and Welsh bards, are less satisfactory than his tables of affinity between the several northern languages, as deduced from one common stock. Literature, however, is much obliged to him for having in this, as well as in many of his other works, opened a new field of observations and discoveries. In enumerating our learned friend's dissertations, we find ourselves at a loss whether we should follow the order of subjects or of time; neither is it easy to account

Parſons. account for their ſurpriſing variety and quick ſucceſſion. The truth is, that his eagerneſs after knowledge was ſuch, as to embrace almoſt with equal facility all its branches, and with equal zeal to aſcertain the merit of inventions, and aſcribe to their reſpective, and ſometimes unknown, authors, the glory of the diſcovery. Many operations, which the ancients have tranſmitted to us, have been thought fabulous, merely from our ignorance of the art by which they were performed. Thus the burning of the ſhips of the Romans at a conſiderable diſtance, during the ſiege of Syracuſe, by Archimedes, would perhaps ſtill continue to be exploded, had not the celebrated M. Buffon in France ſhewn the poſſibility of it, by preſenting and deſcribing a model of a ſpeculum, or rather aſſemblage of mirrors, by which he could ſet fire at the diſtance of ſeveral hundred feet. In the contriving, indeed, though not in the executing of ſuch an apparatus, he had in ſome meaſure been foreſtalled by a writer now very little known or read. This Dr Parſons proved in a very ſatisfactory manner; and he had the pleaſure to find the French philoſopher did not refuſe to the Jeſuit his ſhare in the invention, and was not at all offended by the liberty he had taken. Another French diſcovery, I mean a new kind of painting fathered upon the ancients, was reduced to its real value, in a paper which ſhewed our author was poſſeſſed of a good taſte for the fine arts: and I am informed that his ſkill in muſic was by no means inferior, and that his favourite amuſement was the flute. Richly, it appears from theſe performances, did our author merit the honour of being a member of the Antiquarian Society, which long ago had aſſociated him to its labours. To another ſociety, founded upon the great principles of humanity, patriotiſm, and natural emulation, he undoubtedly was greatly uſeful (A). He aſſiſted at moſt of their general meetings and committees, and was for many years chairman to that of agriculture; always equally ready to point out and to promote uſeful improvements, and to oppoſe the intereſted views of fraud and ignorance, ſo inſeparable from very extenſive aſſociations. No ſooner was *this* ſociety (B) formed, than Dr Parſons became a member of it. Intimately convinced of the nobleneſs of its views, though from his ſtation in life little concerned in its ſucceſs, he grudged neither attendance nor expence. Neither ambitious of taking the lead, nor fond of oppoſition, he joined in any meaſure he thought right; and ſubmitted cheerfully to the ſentiments of the majority, though againſt his own private opinion. The juſt ideas he had of the dignity of our profeſſion, as well as of the common links which ought to unite all its members, notwithſtanding the differences of country, religion, or places of education, made him bear impatiently the ſhackles laid upon a great number of reſpectable practitioners: he wiſhed, fondly wiſhed, to ſee theſe broken; not with a view of empty honour and dangerous power, but as the only means of ſerving mankind more effectually, checking the progreſs of deſigning men and illiterate practitioners, and diffuſing through the whole body a ſpirit of emulation. Though, by frequent diſappointments he ſaw, as well as we, the little chance of a ſpeedy redreſs, he nobly perſiſted in the attempt; and had he lived to the final event, would undoubtedly, like Cato, [illegible] have preferred the conquered cauſe to that ſupported by the gods. After having [illegible] from London, for the ſake of his health, and having diſpoſed of moſt of his books with that view, he found it inconſiſtent with his happineſs to forſake all the advantages which a long reſidence in the capital, and the many connections he had formed, had rendered habitual to him. He therefore returned to his old houſe, and died in it, after a ſhort illneſs, April [illegible] 1770. The ſtyle of our friend's compoſition was ſufficiently clear in deſcription, tho' in argument not ſo cloſe as could have been wiſhed. Full of his ideas, he did not always ſo diſpoſe and connect them together, as to produce in the minds of his readers that conviction which was in his own. He too much deſpiſed thoſe additional graces which command attention when joined to learning, obſervation, and ſound reaſoning. Let us hope that his example and ſpirit will animate all his colleagues; and that thoſe practitioners who are in the ſame circumſtances will be induced to join their brethren, ſure to find among them thoſe great bleſſings of life, freedom, equality, information, and friendſhip. As long as theſe great principles ſhall ſubſiſt in this ſociety, and I truſt they will outlaſt the longeſt liver, there is no doubt but the members will meet with the reward honeſt men are ambitious of, the approbation of their conſcience, the eſteem of the virtuous, the remembrance of poſterity."

PARODICAL DEGREES, in an equation, a term that has been ſometimes uſed to denote the ſeveral regular terms in a quadratic, cubic, biquadratic, &c. equation, when the indices of the powers aſcend or deſcend orderly in an arithmetical progreſſion. Thus $x^3 + mx^2 + nx = p$ is a cubic equation where no term is wanting, but having all its parodic degrees; the indices of the terms regularly deſcending thus, 3, 2, 1, 0.

PARTY ARCHES, in architecture, are arches built between ſeparate tenures, where the property is intermixed, and apartments over each other do not belong to the ſame eſtate.

Party Walls, are partitions of brick made between buildings in ſeparate occupations, for preventing the ſpread of fire. Theſe are made thicker than the external walls; and their thickneſs in London is regulated by act of Parliament of the 14th of George III.

PASSIGRAPHY, the art of writing on any ſubject ſo as to be underſtood by all nations (See *Univerſal* CHARACTERS in this *Supplement*). In France, where every thing is admired that is new, and every vagary of the imagination of a pretended philoſopher thought practicable, a propoſal has lately been made to introduce one univerſal language into the world, conſtructed by a few metaphyſicians on the laws of human thought. And to this language, in its written form, is to be given the name of *paſſigraphy*. Such readers as think this idle dream

(A) The Society for the Encouragement of Arts, Manufactures, and Commerce. He likewiſe was aſſociated to the Economical Society at Berne, Dec. 26. 1763.

(c) A Medical Society inſtituted by Dr Fothergill, and other reſpectable phyſicians, licentiates, in vindication of their privileges; where, it ſhould ſeem, this eulogy was intended to be pronounced.

dream worthy their attention (which is far from being the case with us), will find some ingenious thoughts on the history of a philosophical language, in the 2d volume of *Nicholson's Journal of Natural Philosophy*, &c.

PATH OF THE VERTEX, a term frequently used by Mr Hamilton, in his Doctrine of the Sphere, denoting a circle, described by any point of the earth's surface as the earth turns round its axis. This point is considered as vertical to the earth's centre; and is the same with what is called the vertex or zenith in the Ptolomaic projection.

PEARL FISH, is commonly considered as an *ascidia* (see MYTILUS, *Encycl.*); but this is denied by a late author, who seems to have paid great attention to the pearl fishery at Ceylon. It has never, he says, been accurately described. It does not resemble the *ascidia* of Linnæus; and as he thinks it may form a new genus, he gives the following account of it:

"The fish is fastened to the upper and lower shells by two white flat pieces of muscular substance, which have been called ears, and extend about two inches from the thick part of the body, growing gradually thinner. The extremity of each ear lies loose, and is surrounded by a double brown fringed line. These lie almost the third part of an inch from the outer part of the shell, and are continually moved by the animal. Next to these, above and below, are situated two other double fringed moveable substances, like the bronchiæ of a fish. These ears and fringes are joined to a cylindrical piece of flesh of the size of a man's thumb, which is harder and of a more muscular nature than the rest of the body. It lies about the centre of the shells, and is firmly attached to the middle of each. This, in fact, is that part of the pearl fish which serves to open and shut the shells. Where this column is fastened, we find on the flesh deep impressions, and on the shell various nodes of round or oblong forms, like imperfect pearls. Between this part and the hinge (*cardo*) lies the principal body of the animal, separated from the rest, and shaped like a bag. The mouth is near the hinge of the shell, enveloped in a veil, and has a double flap or lip on each side; from thence we observe the throat (*œsophagus*) descending like a thread to the stomach. Close to the mouth there is a curved brownish tongue, half an inch in length, with an obtuse point; on the concave side of this descends a furrow, which the animal opens and shuts, and probably uses to convey food to its mouth. Near its middle are two bluish spots, which seem to be the eyes. In a pretty deep hole, near the base of the tongue, lies the beard (*byssus*), fastened by two fleshy roots, and consisting of almost 100 fibres, each an inch long, of a dark green colour, with a metallic lustre; they are undivided, parallel, and flattened. In general, the *byssus* is more than three quarters of an inch without the cleft (*rima*); but if the animal is disturbed, it contracts it considerably. The top of each of these threads terminates in a circular gland or head, like the *stigma* of many plants. With this *byssus* they fasten themselves to rocks, corals, and other solid bodies; by it the young pearl-fish cling to the old ones, and with it the animal procures its food, by extending and contracting it at pleasure. Small shell fish, on which they partly live, are often found clinging to the former. The stomach lies close to the root of the beard, and has, on its lower side, a protracted obtuse point. Above the stomach are two small red bodies, like lungs; and from the stomach goes a long channel or gut, which takes a circuit round the muscular column above-mentioned, and ends in the anus, which lies opposite to the mouth, and is covered with a small thin leaf, like a flap. Though the natives pretend to distinguish the sexes by the appearance of the shell, calling the flat ones males, and those which are thick, concave, and vaulted, females, our author, on a close inspection, could not perceive any visible sexual difference."

The pearls are only in the softer part of the animal, and never in the firm muscular column above-mentioned. They are found, in general, near the earth, and on both sides of the mouth. From the appearance of the shell a judgment may be formed, with greater or less probability, whether it contains pearls or not. Those which have a thick calcareous crust upon them, to which *serpulæ* (sea tubes) *Tubuli marini irregulariter intorti*, *Crista gali Chamar lazurus*, *Lepas tintinabulum*, *Madreporee*, *Millipore*, *Cellipore*, *Gorgoniæ*, *Spongiæ*, and other Zoophytes, are fastened, have arrived at their full growth, and commonly contain the best pearls; but those that appear smooth, contain either none, or small ones only.

In the article (*Encycl.*) intitled, *Manner of Fishing for* PEARLS *in the East Indies*, we have most unaccountably said, that "the best divers will keep under water near *half an hour*, and the rest not less than a quarter!" This is a very great mistake; for M. *Le Beck* assures us, that the time during which a diver is able to remain under water seldom exceeds two minutes; and that, even after that short period, he discharges, on emerging from the sea, a quantity of water, and sometimes a little blood, from his mouth and nose. We have mentioned the danger which the divers run of becoming a prey to monstrous fishes. These fishes are sharks; of which such a dread is justly entertained, that the most expert divers will not, on any account, descend, till the conjurer has performed his ceremonies of inchantment. These consist in a number of prayers, learned by heart, that nobody, probably not even the conjurer himself, understands, which he, standing on the shore, continues muttering and grumbling from sun rise until the boats return. During this period, he is obliged to abstain from food and sleep, otherwise his prayers would have no avail: he is, however, allowed to drink; which privilege he indulges in a high degree, and is frequently so giddy, as to be rendered very unfit for devotion. Some of the conjurers accompany the divers in their boats; which pleases them very much, as they have their protectors near at hand.

PEDOMETER (see *Encycl.*), is the name given by Mr Lewin Thugwell to an instrument, which is rather an improved PERAMBULATOR than the instrument which we have noticed by the name of Pedometer. The chief improvement made by him on the PERAMBULATOR (see that article, *Encycl.*) is in the size of the wheel, of which the circumference measures 16½ feet, or one pole, adapted to Gunter's concise method of arithmetic, and divided into 25 equal parts, corresponding to the links of his chain for land measuring. There is likewise a contrivance in Mr Thugwell's pedometer, for compelling the attention of the traveller to the instrument at the end of every mile. It is very ingenious, and abundantly simple; but we hardly think it of sufficient

Pegue. cient importance to fill the ſpace which a complete deſcription of it would occupy in this Work. It is fully deſcribed in the *Letters and Papers of the Bath and Weſt of England Society, for the Encouragement of Agriculture;* and likewiſe in the 6th volume of the *Repertory of Arts and Manufactures.*

PEGUE, the ancient capital of the kingdom of the ſame name (ſee PEGU, *Encycl.*), appears to have been a quadrangle, each ſide meaſuring about a mile and a half. It was ſurrounded by a ditch and wall; which, before the latter tumbled down, and the former was filled up, muſt have furniſhed no contemptible defence. The breadth of the ditch appears to be about 60 yards; its depth, where not choked up, about ten or twelve feet; and there is ſtill in it water enough to impede an eaſtern ſiege. The wall has been at leaſt 25 feet high, and its breadth at the baſe not leſs than 40. It is compoſed of brick, badly cemented together with clay mortar, and has ~~had on it ſmall~~ equidiſtant baſtions, about 300 yards aſunder.

Nothing can exhibit a more ſtriking picture of deſolation than the inſide of this wall. We have elſewhere given an account of the almoſt inceſſant wars between the kings of Pegue and Birma or Barma. In the year 1757, the Birman ſovereign carried the city of Pegue by aſſault, razed every dwelling to the ground, and diſperſed, or led into captivity, all the inhabitants. The pagodas, which are very numerous, were the only buildings that eſcaped the fury of the conqueror; and of theſe the great pagoda of SHOEMADOO has alone been attended to, and repaired.

This extraordinary edifice is built on a double terrace, one raiſed upon another. The lower and greater terrace is about ten feet above the natural level of the ground. It is quadrangular. The upper and leſſer terrace is of a like ſhape, raiſed about 20 feet above the lower terrace, or 30 above the level of the country. Theſe terraces are aſcended by flights of ſtone ſteps, broken and neglected. On each ſide are dwellings of the *Rahaans* or prieſts, raiſed on timbers four or five feet from the ground. Their houſes conſiſt only of a ſingle hall. The wooden pillars that ſupport them are turned with neatneſs. The roof is of tile, and the ſides of ſheathing-boards. There are a number of bare benches in every houſe, on which the *Rahaans* ſleep. They appear to have no furniture.

Shoemadoo is a pyramid, compoſed of brick and plaſter, with fine ſhell mortar, without excavation or aperture of any ſort; octagonal at the baſe, and ſpiral at the top. Six feet from the ground there is a wide ledge, which ſurrounds the baſe of the building; on the plane of which are 57 ſmall ſpires, of equal ſize, and equidiſtant. One of them meaſured 27 feet in height, and 40 in circumference at the bottom. On a higher ledge there is another row, conſiſting of 53 ſpires, of ſimilar ſhape and meaſurement. A great variety of mouldings encircles the building; and ornaments, ſomewhat reſembling the *fleur de lys*, ſurround what may be called the baſe of the ſpire. Circular mouldings likewiſe gird this part to a conſiderable height; above which there are ornaments in ſtucco, not unlike the leaves of a Corinthian capital; and the whole is crowned by a *tee*, or umbrella of open iron-work, from which riſes an iron rod with a gilded penant.

The extreme height of the building, from the level of the country, is 361 feet; and above the interior terrace, 331 feet. On the ſouth eaſt angle of the upper terrace there are two handſome ſaloons, or *leouns*, lately erected. The roof is compoſed of different ſtages, ſupported by pillars. Captain Symes, from whoſe memoir in the Aſiatic Reſearches this account is taken, judged the length of each ſaloon to be about 6. feet, and the breadth 30. The ceiling of one of them was already embelliſhed with gold leaf, and the pillars lacquered; the other, when he ſaw it, was not completed. They are made entirely of wood. The carving on the outſide is very curious. He ſaw ſeveral unfiniſhed figures, intended to be fixed on different parts of the building; ſome of them not ill ſhapen, and many exceedingly groteſque. Splendid images of Gaudma (the *Birman* object of adoration) were preparing, which he underſtood were deſigned to occupy the inſide of theſe *leouns*.

At each angle of the interior terrace is a pyramidical pagoda, 67 feet in height, reſembling, in miniature, the great pagoda. In front of the one in the ſouth weſt corner are four gigantic repreſentations in maſonry of Palloo, or the *man deſtroyer*, half beaſt, half human, ſeated on their hams, each with a large club on the right ſhoulder.

Nearly in the centre of the eaſt face of the area are two human figures in ſtucco beneath a gilded umbrella. One ſtanding, repreſents a man with a book before him, and a pen in his hand. He is called *Thagiamee*, the recorder of mortal merits and mortal miſdeeds. The other, a female figure kneeling, is *Maha Sumdere*, the protectreſs of the univerſe, as long as the univerſe is doomed to laſt: but when the time of general diſſolution arrives, by her hand the world is to be overwhelmed, and deſtroyed everlaſtingly.

On the north ſide of the great pagoda are three large bells, of good workmanſhip, ſuſpended near the ground between pillars. Several deers horns are ſtrewed around. Thoſe who come to pay their devotions firſt take up one of the horns, and ſtrike the bell three times, giving an alternate ſtroke to the ground. This act is to announce to the ſpirit of Gaudma the approach of a ſuppliant. There are ſeveral low benches near the bottom of the pagoda, on which the perſon who comes to pray places his offering; which generally conſiſts of boiled rice, a plate of ſweetmeats, or cocoa-nut fried in oil. When it is given, the devotee cares not what becomes of it. The crows and dogs commonly eat it up in the preſence of the donor, who never attempts to prevent or moleſt the animals.

There are many ſmall pagodas on the areas of both terraces, which are neglected, and ſuffered to fall into decay. Numberleſs images of Gaudma lie indiſcriminately ſcattered. A pious Birman who purchaſes an idol, firſt procures the ceremony of conſecration to be performed by the *Rahaans*, then takes his purchaſe to whatever ſacred building is moſt convenient, and there places it either in the ſhelter of a *leoun*, or on the open ground before the temple: nor does he ever after ſeem to have any anxiety about its preſervation, but leaves the divinity to ſhift for itſelf.

From the upper ledge that ſurrounds the baſe of Shoemadoo, the proſpect of the country is extenſive and pictureſque; but it is a proſpect of Nature in her rudeſt ſtate. There are few inhabitants, and ſcarcely any

Pegue. any cultivation. The hills of *Martaban* riſe to the eaſtward; and the *Sitang* river, winding along the plains, gives here and there an interrupted view of its waters. To the north-north weſt, above 40 miles, are the *Galladzet* hills, whence the Pegue river takes its riſe; hills remarkable only for the noiſome effects of their atmoſphere. In every other direction the eye looks over a boundleſs plain, chequered by a wild intermixture of wood and water.

The preſent king of the Birmans has entirely altered the ſyſtem of his predeceſſors. He has turned his attention to the population and improvement, rather than the extenſion, of his dominions; and ſeems more deſirous to conciliate his new ſubjects by mildneſs, than to rule them through terror. He has abrogated ſeveral ſevere penal laws impoſed upon the *Taliens* or Peguers: juſtice is now diſtributed impartially; and the only diſtinction at preſent between a Birman and Talien conſiſts in the excluſion of the latter from all public offices of truſt and power.

No act of the Birman government is more likely to reconcile the Taliens to the Birman yoke than the reſtoration of their ancient place of abode, and the preſervation and embelliſhment of the pagoda of Shoemadoo. So ſenſible was the king of this, as well as of the advantages that muſt accrue to the ſtate from an increaſe of culture and population, that ſome years ago he iſſued orders to rebuild Pegue, encouraged new ſettlers by liberal grants, and invited the ſcattered families of former inhabitants to return and repeople their deſerted city.

Pegue, in its renovated ſtate, ſeems to be built on the plan of the former city. It is a ſquare, each ſide meaſuring about half a mile. It is fenced round by a ſtockade, from 10 to 12 feet high. There is one main ſtreet running eaſt and weſt, which is interſected at right angles by two ſmaller ſtreets, not yet finiſhed. At each extremity of the principal ſtreet there is a gate in the ſtockade, which is ſhut early in the evening. After that hour, entrance during the night is confined to a wicket. Each of theſe gates is defended by a ſorry piece of ordnance, and a few muſqueteers, who never poſt centinels, and are uſually aſleep. There are alſo two other gates on the north and ſouth ſides of the ſtockade.

The houſes of the inhabitants of Pegue are far from commodious, agreeably to European notions of accommodation; but they are at leaſt as much ſo as the houſes of other Indian towns. There are no brick buildings in Pegue, except ſuch as belong to the king, or are dedicated to Gaudma. The king has prohibited the uſe of brick or ſtone in private buildings, from the apprehenſion, that if people got leave to build brick houſes, they might erect brick fortifications, dangerous to the ſecurity of the ſtate. The houſes, therefore, are all made of mats or ſheathing boards, ſupported on bamboos or poſts. Being compoſed of ſuch combuſtible materials, the inhabitants are under continual dread of fire, againſt which they take every precaution. The roofs are lightly covered; and at each door ſtands a long bamboo, with a hook at the end, to pull down the thatch; alſo another pole, with a grating of ſplit bamboo at the extremity, about three feet ſquare, to ſuppreſs flame by preſſure. Almoſt every houſe has earthen pots of water on the roof. And there is a particular claſs of people, whoſe buſineſs it is to prevent and extinguiſh fires.

PEISHCAR, in Bengal, principal in office.

PEISHCUSH, a fine, tribute, or preſent.

PELL (Dr John), an eminent Engliſh mathematician, deſcended from an ancient family in Lincolnſhire, was born at Southwick in Suſſex, March 1. 1610, where his father was miniſter. He received his grammar education at the free ſchool at Stenning in that county. At the age of 13 he was ſent to Trinity college in Cambridge, being then as good a ſcholar as moſt maſters of arts in that univerſity; but though he was eminently ſkilled in the Greek and Hebrew languages, he never offered himſelf a candidate at the election of ſcholars or fellows of his college. His perſon was handſome; and being of a ſtrong conſtitution, uſing little or no recreations, he proſecuted his ſtudies with the more application and intenſeneſs.

In 1629 he drew up the "Deſcription and Uſe of the Quadrant, written for the Uſe of a Friend," in two books; the original manuſcript of which is ſtill extant among his papers in the Royal Society. And the ſame year he held a correſpondence with Mr Briggs on the ſubject of logarithms.

In 1630, he wrote *Modus ſupputandi Ephemerides Aſtronomicas, &c. ad an.* 1630 *accommodatus;* and, A Key to unlock the meaning of Johannes Trithemius, in his Diſcourſe on Steganography: which Key he imparted to Mr Samuel Hartlib and Mr Jacob Homedæ. The ſame year he took the degree of Maſter of Arts at Cambridge. And the year following he was incorporated in the univerſity of Oxford. June the 7th, he wrote A Letter to Mr Edmond Wingate on Logarithms: and, Oct. 5. 1631, *Commentationes in Coſinographiam Alſtedii.*

In 1632 he married Ithamaria, ſecond daughter of Mr Henry Reginolles of London, by whom he had four ſons and four daughters.—March 6. 1634, he finiſhed his "Aſtronomical Hiſtory of Obſervations of Heavenly Motions and Appearances;" and April the 10th, his *Ecliptica Prognoſtica*, or Foreknower of the Eclipſes, &c. In 1634 he tranſlated "The Everlaſting Tables of Heavenly Motions," grounded upon the Obſervations of all Times, and agreeing with them all, by Philip Lanſberg, of Ghent in Flanders. And June the 12th, the ſame year, he committed to writing "The Manner of Deducing his Aſtronomical Tables out of the Tables and Axioms of Philip Lanſberg."—March the 9th, 1625, he wrote "A Letter of Remarks on Gellibrand's Mathematical Diſcourſe on the Variation of the Magnetic Needle" And the 3d of June following, another on the ſame ſubject.

His eminence in mathematical knowledge was now ſo great, that he was thought worthy of a Profeſſor's chair in that ſcience; and, upon the vacancy of one at Amſterdam in 1639, Sir William Boſwell, the Engliſh Reſident with the States General, uſed his intereſt, that he might ſucceed in that Profeſſorſhip. It was not filled up, however, till 1643, when Pell was choſen to it; and he read with great applauſe public lectures upon Diophantus.—In 1644 he printed at Amſterdam, in two pages 4to, "A Refutation of Longomontanus's Diſcourſe," *De Vera Circuli Menſura.*

Pell.

In 1646, on the invitation of the Prince of Orange, he removed to the new college at Breda, as Professor of Mathematics, with a salary of 1000 guilders a year. His *Idea Matheseos*, which he had addressed to Mr Hartlib, who in 1639 had sent it to Des Cartes and Mersenne, was printed 1650 at London, in 12mo, in English, with the title of *An Idea of Mathematics*, at the end of Mr John Durie's Reformed Library keeper. It is also printed by Mr Hook, in his Philosophical Collections, N° 5. p. 127.; and is esteemed our author's principal work.

In 1652 Pell returned to England; and in 1654 he was sent by the protector Cromwell agent to the Protestant Cantons in Switzerland; where he continued till June 23. 1658, when he set out for England, where he arrived about the time of Cromwell's death. His negociations abroad gave afterwards a general satisfaction, as it appeared he had done no small service to the interest of King Charles II. and of the church of England; so that he was encouraged to enter into holy orders: and in the year 1661 he was instituted to the rectory of Fobbing in Essex, given him by the king. In December that year, he brought into the upper house of convocation the calendar reformed by him, assisted by Sancroft, afterwards archbishop of Canterbury. In 167 he was presented by Sheldon, bishop of London, to the rectory of Laingdon in Essex; and, upon the promotion of that bishop to the see of Canterbury soon after, became one of his domestic chaplains. He was then doctor of divinity, and expected to be made a dean; but his improvement in the philosophical and mathematical sciences was so much the bent of his genius, that he did not much pursue his private advantage. The truth is, he was a helpless man, as to worldly affairs; and his tenants and relations imposed upon him, cozened him of the profits of his parsonage, and kept him so indigent, that he wanted necessaries, even ink and paper, to his dying day. He was for some time confined to the King's-bench prison for debt; but, in March 1682, was invited by Dr Whitler to live in the college of physicians. Here he continued till June following; when he was obliged, by his ill state of health, to remove to the house of a grandchild of his in St Margaret's church-yard, Westminster. But he died at the house of Mr Cothorne, reader of the church of St Giles's in the Fields, December the 12th, 1685, in the 74th year of his age, and was interred at the expence of Dr Busby, master of Westminster school, and Mr Sharp, rector of St Giles's, in the rector's vault under that church.—Dr Pell published some other things not yet mentioned; a list of which is as follows, *viz.*

1. An Exercitation concerning Easter; 1644, in 4to. 2. A Table of 10,000 square numbers, &c.; 1672, folio. 3. An Inaugural Oration at his entering upon the Professorship at Breda. 4. He made great alterations and additions to Rhonius's Algebra, printed at London 1668, 4to, under the title of An Introduction to Algebra, translated out of the High Dutch into English by Thomas Branker, much altered and augmented by D. P. (Dr Pell). Also a Table of Odd Numbers, less than 100,000, shewing those that are incomposite, &c. supputated by the same Thomas Branker. 5. His Controversy with Longomontanus concerning the Quadrature of the Circle; Amsterdam, 1646, 4to.

Pell
Pelletier.

He likewise wrote a Demonstration of the 2d and 10th books of Euclid; which piece was in MS. in the library of Lord Brereton in Cheshire: as also Archimedes's Arenarius, and the greatest part of Diophantus's six books of Arithmetic; of which author he was preparing, August 1644, a new edition, in which he intended to correct the translation, and make new illustrations. He designed likewise to publish an edition of Apollonius; but laid it aside, in May 1645, at the desire of Golius, who was engaged in an edition of that author from an Arabic manuscript, given him at Aleppo 18 years before. Letters of Dr Pell to Sir Charles Cavendish, in the Royal Society.

Some of his manuscripts he left at Brereton in Cheshire, where he resided some years, being the seat of William Lord Brereton, who had been his pupil at Breda. A great many others came into the hands of Dr Busby; which Mr Hook was desired to use his endeavours to obtain for the Society. But they continued buried under dust, and mixed with the papers and pamphlets of Dr Busby, in four large boxes, till 1755; when Dr Birch, secretary to the Royal Society, procured them for that body, from the trustees of Dr Busby. The collection contains, not only Pell's mathematical papers, letters to him, and copies of those from him, &c. but also several manuscripts of Walter Warner, the mathematician and philosopher, who lived in the reigns of James I. and Charles I.

Dr Pell invented the method of ranging the several steps of an algebraical calculus, in a proper order, in so many distinct lines, with the number affixed to each step, and a short description of the operation or process in the line. He also invented the character ÷ for division, ⊕ for involution, ω for evolution *.

PELLETIER (Bertrand), was born at Bayonne in 1761, and very soon began to display an insatiable thirst of science. It frequently happens, however, that young men, sincerely desirous of instruction, have no means or place where they can be assisted in the developement of their natural talents, no master who may point out the direct road to science, and that order and method, without which the efforts of the individual too often lead him from the object of his pursuit, instead of bringing him nearer to it. This was not the case with young Pelletier. He found every advantage in his father's house, where he received the first elements of the art of which he was afterwards the ornament; and his subsequent progress was made under Darcet, who having remarked in him that sagacity which may be called the instinct of science, admitted him among the pupils attached to the chemical laboratory of the college of France. Five years of constant application and study under such a master, who was himself formed by nature, perfected by experience, and affectionately disposed towards his pupil, afforded this young man a stock of knowledge very unusual at his age. He soon gave a convincing proof of this, by publishing, at the age of 21, a set of very excellent observations on the arsenical acid. Macquer, by mixing nitre with the oxyd of arsenic, had discovered in the residue of this operation a salt soluble in water, susceptible of crystallization in tetrahedral prisms, which he denominated the neutral

* *Hutton's Mathematical Dictionary.*

arsenical salt. It is the arseniat of potash. He was of opinion that no acid could decompose it; but Pelletier shewed, that the sulphuric acid distilled from it does disengage the acid of arsenic. He shewed the true cause why the neutral arsenical salt is not decomposable in closed vessels; and particularly the order of affinity by which the salt itself is formed in the distillation of the nitrate of potash, and the white oxyd of arsenic. He explains in what respects this salt differs from what Macquer called the liver of arsenic. Pelletier had been anticipated in this work by Scheele, by Bergman, by the academicians of Dijon, and by Berthollet; but he possessed at least the merit, in the first essay of his powers, of having clearly developed all the phenomena of this operation, by retaining and even determining the quantity of gas it was capable of affording. After the same principles it was that he decomposed the arsenico-ammoniacal salt, by shewing how, in the decomposition of this last, the pure arsenical acid is obtained in the form of a deliquescent glass. In this work we may observe the sagacity with which he was enabled to develope all the phenomena of these compositions and decompositions, by tracing those delicate threads of scientific relation which connect the series of facts, and are imperceptible to ordinary minds.

Encouraged by the success of these first works, which he presented with the sensibility of grateful attachment to his instructor, he communicated his observations on the crystallization of sulphur, cinnabar, and the deliquescent salts; the examination of zeolites, particularly the false zeolite of Fribourg in Brisgaw, which he found to be merely an ore of zinc; observations on the dephlogisticated or oxygenated muriatic acid, relative to the absorption of oxygen; on the formation of ethers, particularly the muriatic and the acetous; and several memoirs on the operation of phosphorus made in the large way; its conversion into phosphoric acid, and its combination with sulphur and most metallic substances.

It was by his operations on that most astonishing production of chemistry, phosphorus, that he burned himself so dangerously as nearly to have lost his life. After the cure of his wound, which confined him to his bed for six months, he immediately began the analysis of the various plumbagos of France, England, Germany, Spain, and America, and found means to give novelty and interest to his work, even after the publication of Scheele on the same object. The analysis of the carbonat of barytes led him to make experiments on animals; which prove that this earth is a true poison, whether it be administered in the form of the native carbonat of barytes, or whether it be taken from the decomposition of the sulphat, even though again combined with another acid.

Chemists have given the name of *strontian* to a newly discovered earth, from the name of the place where it was first found. Pelletier analysed it, and discovered it in the sulphat of barytes. He likewise analysed the verditer of England, of which painters and paper-hangers make so much use. He discovered a process for preparing it in the large way, by treating with lime the precipitate obtained from the decomposition of nitrat of copper by lime. By his process, verditer is afforded equal in beauty to that which comes from England. He was likewise one of the first chemists who shewed the possibility of refining bell metal, and separating the tin. His first experiments were made at Paris; after which he repaired to the foundry at Romilly, to verify them in the large way. The following year he was received a member of the Academy of Sciences at Paris, and shortly afterwards went to La Fere, with Borda and General Daboville, to assist in experiments upon a new gunpowder. Being obliged, in order to render his experiments more decisive, to pass great part of the day in the open air during a cold and humid season, his health, which was naturally delicate, became considerably impaired. He began to recover his health, when he again became the victim of his zeal for the science he so successfully cultivated. He had nearly perished by respiring the oxygenated muriatic acid gas. A violent attack of convulsive asthma, which returned during several days, was the first consequence of this unhappy accident. The disorder then seemed to abate; but it was incurable. The assistance of art was insufficient to save him; and he died in Paris, on the 21st of July 1797, of a pulmonary consumption, in the flower of his age.

PENDULUM (See *Encycl.*). Besides the effects of heat and cold on the length of the pendulum rod, and of course on its isochronism, it may certainly be worth while, in the construction of clocks intended to measure time with the utmost possible exactness, to take into consideration the resistance of the air, which, by its unequal density, varying the weight of the pendulum, must in a small degree accelerate or retard its motion. The celebrated David Rittenhouse, who paid particular attention to this subject, estimates the extreme difference of velocity, arising from this cause, at half a second a day; and he observes, that a remedy dependent on the barometer will not be strictly accurate, as the weight of the entire column of air does not precisely correspond with the density of its base. He proposes, therefore, as a very simple and easy remedy, that the pendulum shall, as usual, consists of an inflexible rod carrying the ball beneath, and continued above the centre of suspension to an equal (or an unequal) distance upwards. At this extremity is to be fixed another ball of the same dimensions (or greater or less, according as the continuation is shorter or longer), but made as light as possible. The oscillations of this upper ball will be accelerated by its buoyancy by the same quantity as those of the lower would be retarded; and thus, by a proper adjustment, the two effects might be made to balance and correct each other.

Our author made a compound pendulum on these principles, of about one foot in its whole length. This pendulum, on many trials, made in the air 57 vibrations in a minute. On immersing the whole in water, it made 59 vibrations in the same time; shewing evidently, that its returns were quicker in so dense a medium as water than in the air. (This is contrary to what takes place with the common pendulum). When the lower bob or pendulum only was plunged in water, it made no more than 44 vibrations in a minute.

PENNANT (Thomas, Esq.), so well known in the republic of letters as a writer of travels and of natural history, was an ancient Briton by birth, having drawn his first breath in Flintshire, in 1726. His family has been settled in that county for many centuries; we learn from himself that he received the rudiments of his education at Wrexham, whence he was removed to Fulham. Soon after this he was sent to Oxford; and having

Pennant. ving made a considerable proficiency in the classics, he applied himself within the walls of that university to attain a knowledge of jurisprudence; but we do not find that he ever entered himself of any of the inns of court, or followed the law as a profession.

The ruling passions of mankind are excited, and the future current of their lives frequently directed, by trivial circumstances. One of the greatest painters of our age was attracted with an irresistible impulse towards his art by the perusal of a treatise on it; and we have the authority of the subject of this memoir for asserting, that a present of Willughby's Ornithology, at an early period, first gave him a turn for natural history, which has never once abandoned him through the course of a very long life.

Mr Pennant commenced his travels with great propriety at home, where he made himself acquainted with the manners, productions, and curiosities, of his native country, before he sallied forth to inspect those of other nations. ~~He then repaired to~~ the continent; and not only acquired considerable additional knowledge relative to his favourite studies, but became acquainted, and established a correspondence, with some of the greatest men of the age.

On his return he married, and had two children, but did not come into the family fortune until he was thirty-seven years of age, at which time he was settled at Downing.

Having lost his wife, he appears to have set out once more for the continent, and to have formed an acquaintance with Voltaire, Buffon, Haller, Pallas, &c. He had by this time acquired considerable reputation as a scientific man, having commenced his career as an author so early as 1750. His British Zoology * established his reputation as a naturalist; and this received a fresh accession of celebrity in consequence of his acquaintance with Linnæus, and his intercourse by letters with all the celebrated naturalists in Europe.

* Four vols 4to.

Early in life he had undertaken a most interesting tour to Cornwall; and he now entertained an ardent desire to survey the works of nature in the northern extremities of the island. He accordingly set out for Scotland, and in 1771 favoured the public with an entertaining account of his Tour †, which was so well received as to pass through several editions. Not content with the main land of Great Britain, he was ambitious to survey the islands in the vicinity, and accordingly penetrated to the Hebrides, and visited Man.

† Three vols 4to.

It is not to be supposed that he would leave his own country unexplored; on the contrary, he minutely described all its wonders. He did not fail on this occasion to present the world with the result of his enquiries, for in 1778 he commenced the publication of his Welch Tour §.

§ Two vols 4to.

In four years after this (1782) appeared the account of the Journey from Chester to London ‡, in which he refutes the vulgar opinion that it is uninteresting; and in two years more his Arctic Zoology, an admirable work, greatly prized both here and in other countries.

‡ One vol. 4to.

In 1790 appeared a quarto volume, simply entitled Of London; in which he observes that this work is composed from observations, originally made without any view of publication. "Let me request (says he in the preface) the good inhabitants of London and Westminster not to be offended at my having stuffed their Iliad into a nutshell; the account of the city of London and liberties of Westminster into a quarto volume. I have condensed into it all I could; omitted nothing that suggested itself; nor amplified any thing to make it a guinea book. In a word, it is done in my own manner, from which I am grown too old to depart.

"I feel within myself a certain monitor that warns me (adds he) to hang up my pen in time, before its powers are weakened, and rendered visibly impaired. I wait not for the admonition of friends. I have the Archbishop of Grenada in my eye; and fear the imbecility of human nature might produce in long-worn age the same treatment of my kind advisers as poor Gil Blas had from his most reverend patron. My literary bequests to future times, and more serious concerns, must occupy the remnant of my days. This closes my public labours."

Notwithstanding his parting address, the example of the Archbishop of Grenada, and the concluding sentence of "*Valete & Plaudite*," we find Mr Pennant adventuring once more in the ocean of literature, at a late period of his life, and trying his fortune again with all the eagerness of a young author.

He accordingly published the Natural History of the parishes of Holywell and Downing *, within the precincts of the latter of which he had resided about half a century.

* One vols 4to.

He also presented the public, a very short time before his death, with a splendid work, consisting of 2 vols. 4to. entitled The View of Hindoostan; in the preface to which he candidly states his motives for this new attempt. "I had many solicitations from private friends (says he), and a few wishes from persons unknown, delivered in the public prints, to commit to the press a part, in the form in which the posthumous volumes might hereafter make their appearance. I might have pleaded the imprudence of the attempt at my time of life, of beginning so arduous an undertaking in my 71st year.

"I happily, till very lately, had scarcely any admonition of the advanced season. I plunged into the sea of trouble, and with my papers in one hand, made my way through the waves with the other, and brought them secure to land. This, alas! is finite boasting. I must submit to the judgment of the public, and learn from thence how far I am to be censured for so grievous an offence against the maxim of Aristotle, who fixes the decline of human abilities to the 49th year.

"I ought to shudder, when I consider the wear and tear of 22 years; and feel shocked at the remark of the elegant Delanty, who observes, 'that it is generally agreed among wise men, that few attempts, at least in a learned way, have ever been wisely undertaken and happily executed after that period!'

"I cannot defend the wisdom: yet from the good fortune of my life I will attempt the execution."

These valuable volumes are drawn up by Mr Pennant in the manner of his introduction to the Arctic Zoology. The plates, 23 in number, are admirably engraved, and one (the Napaul pheasant) is beautifully coloured.

In addition to the list of literary labours already enumerated, is a letter on an earthquake felt at Downing, in Flintshire, in 1753; another inserted in the same publi-

Pennant. publication *, in 1756, on coralloid bodies (*[illegible]*) collected by him: his Synopsis of Quadrupeds, published in 1771; a pamphlet on the Militia; a paper on the Turkey; and a volume of Miscellanies.

* *Phil. Trans.*

Mr Pennant attained academical honours of all kinds, having had the degree of LL. D. conferred on him by the university in which he was educated, he was a Fellow of the Royal Society, and a member of the Society of Antiquaries, a Fellow of the Royal Society of Upsal in Sweden, a member of the American Philosophical Society, an honorary member of the Anglo-Linnæan Society, &c.

The ample fortune left him by his father enabled Mr Pennant to keep an hospitable table, and also to present the profits of several of his works to public institutions, particularly the Welsh charity-school in Gray's-inn-lane. He encouraged several engravers by his patronage, and was not a little serviceable to the advancement of the fine arts.

In 1776 he married a second time; on which occasion he became united to Miss Mostyn, sister of his neighbour, the late Sir Roger Mostyn, in Flintshire. The latter part of his life was chearful, and he scarcely felt the approaches of old age. He died at his seat at Downing in his 72d year.

He has left several works behind him in MS. under the title of Outlines of the Globe; and as a proof that it will be a very voluminous and interesting publication, it is only necessary to observe, that The View of Hindoostan composed the xivth and xvth volumes.

Mr Pennant possessed a well-compacted frame of body, an open and intelligent aspect, an active and chearful disposition, and a vivacity which rendered him always entertaining, as well in conversation as in writing. Though not without a share of irrascibility, his heart was kind and benevolent. He was exemplary in the relations of domestic life, and sensibly felt for the distresses of his poor neighbours, whose relief in seasons of hardship he promoted with great zeal and liberality. His candour and freedom from ordinary prejudices, are sufficiently displayed in his writings; and Scotland was forward to confess, that he was the first traveller from this side the Tweed, who had visited the country with no unfriendly spirit, and had fairly presented it under its favourable as well as its less pleasing aspects. As a writer, his style is lively and expressive, but not perfectly correct. His principles of arrangement in zoology are judicious, and his descriptions characteristic. If in some of his later works a little vanity appears, and a propensity to think that important to the world which was so to himself, it may readily be pardoned to one who has afforded such copious and valuable entertainment to the public. His name will live with honour in the literary history of his country, and his memory will be cherished with respect and affection by his surviving friends.

PENNATULA (See *Encycl.*). A species of this animal, hitherto undescribed, was discovered by La Martiniere near Nootka. Its body is of a cartilaginous substance, and a cylindrical form; its head, armed with two little horns of the same substance, presents a spherical figure flatted at its anterior extremity. This part is covered with small papillæ, some of which are visible at D, and which serve the purpose of small mouths, by means of which this animal sucks the blood of fishes, making its way as far as possible into the flesh: the extremity of its body, which always projects from the fish, appears like the feathers of a pen; these feather-like substances serve as excretory vessels; for on making a slight pressure on the animal, from the greater part of these cartilaginous barbs issued small drops of a very limpid liquor: at the base of these barbs, and beneath the body, are placed two large cartilaginous threads, of which our author could not imagine the use, for they are not universally met with in each individual. The circulation of its blood is readily observed, it forms a complete revolution about once in a minute. It is probable that this animal is only able to make its way into the bodies of different fish when it is very young; and when it has once buried itself there, having abundance of nourishment, its head increases considerably, and the two horns with which it is furnished necessarily form an obstacle to its regress, which is a remarkable instance of the foresight of Nature, since it is destined ~~to be nourished~~ at the expence of another. The pennatula, of which we have given from Martiniere a figure, was found by him at the depth of more than an inch and an half in the body of a *diodon*.

Plate XLI

Pepusch.

PEPUSCH (John Christopher), one of the greatest theoretic musicians of modern times, as we are told, was born at Berlin about 1667; and became so early a proficient on the harpsichord, that at the age of 14 he was sent for to court, and appointed to teach the prince, father of the late King of Prussia. About 1700, he came over to England, and was retained as a performer at Drury Lane: it is supposed that he assisted in composing the operas which were performed there. While he was thus employed, he forebore not to prosecute his private studies; and these led him to enquire into the music of the ancients, and the perusal of the Greek authors upon that subject. The abilities of Pepusch, as a practical composer, were not likely to become a source of wealth to him: his music was correct, but it wanted variety of modulation. Besides, Handel had got possession of the public ear, in the opinion of whose superior merit he readily acquiesced; and chose a track for himself, in which he was almost sure to meet with no obstruction. He became a teacher of music, not the practice of any particular instrument, but music in the absolute sense of the word, that is to say, the principles of harmony and the science of practical composition; and this, not to children or novices, but in very many instances to professors of music themselves.

In 1713, he was admitted to the degree of Doctor in Music at Oxford, and continued to prosecute his studies with great assiduity. In 1724, he accepted an offer from Dr Berkeley to accompany him to the Bermudas, and to settle as professor of music in his intended college there; but the ship in which they sailed being wrecked, he returned to London, and married Francesca Margarita de l'Epine. This person was a native of Tuscany, and a celebrated singer, who performed in some of the first of the Italian operas that were represented in England. She came hither with one Greber, a German, and from this connection became distinguished by the invidious appellation of *Greber's Peg*. Afterwards she commenced a new connection with Daniel Earl of Nottingham, who had defended the orthodox notion of the Trinity against the heretic Whiston; and to this connection Rowe, in imitation of

Horace's,

Pepusch. Horace's, "Ne sit ancillæ tibi amor pudori," thus alludes:

> Did not base Greber's Peg inflame
> The sober Earl of Nottingham,
> Of sober sire descended?
> That, careless of his soul and fame,
> To play-houses he nightly came,
> And left church undefended.

She continued to sing on the stage till about 1718; when having, at a modest computation, acquired above ten thousand guineas, she retired from the theatre, and afterwards married Dr Pepusch. She was remarkably tall, and remarkably swarthy; and, in general, so destitute of personal charms, that Pepusch seldom called her by any other name than Hecate, to which she is said to have answered very readily.

The change in Pepusch's circumstances by Margarita's fortune was no interruption to his studies: he loved music, and he pursued t[illegible]owledge of it with ardour. At the instance of Gay an[illegible]ich, he undertook to compose, or rather to correct, the [illegible] for the Beggar's Opera. His reputation was now at a great height. He had perused with great attention those several ancient treatises on Harmonics, published by Meibomius, and that of Ptolemy by Dr Wallis; and the difficulties which occurred to him on the perusal, were in a great measure removed by his friend De Moivre the mathematician, who assisted him in making calculations for demonstrating those principles on which the harmonic science is founded. In consequence of these studies, he was esteemed, in matters of theory, one of the best musicians of his time. In 1737, he was chosen organist of the Charter-house, and retired, with his wife, to that venerable mansion. The wife died in 1740, before which he lost a son, his only child; so that he had no source of delight left, but the prosecution of his studies, and the teaching of a few favourite pupils, who attended him at his apartments. Here he drew up that account of the ancient genera which was read before the Royal Society, and is published in the Philosophical Transactions for October, November, and December, 1746; and, soon after the publication of that account, he was chosen a Fellow of the Royal Society.

He died the 20th of July, 1752, aged 85; and was buried in the chapel of the Charter-house, where a tablet with an inscription is placed over him *.

PERCUSSION, Force of Percussion, is the name by which mechanicians distinguish that faculty of producing motion, or making other sensible mechanical impressions on bodies, by means of the stroke of a body in motion. It is nearly the same with *impul[illegible]* only, it would seem that the very scrupulous and refined affect to limit the attention to the *immediate* cause of the motion, or other effect produced; to the something that is different, both from the force supposed to be inherent in the moving body (a hammer for example), and the subsequent motion and penetration of the nail which is driven by it. We may venture to say that it is needless to attempt any investigation of this object. It is hid, with all other causes of all other effects in the universe, in impenetrable darkness. If we reflect on the constitution of our own mind, so far as we can know it by experience and observation, and on the manner in which we draw conclusions, we must see that the knowledge of the efficient cause of any effect is unattainable; for were the intervening something pointed out to us, and clearly conceived by us, we should find it just as necessary to find out why and how this something is connected with each of the events which we observe it invariably to connect. Percussion.

But a knowledge of the force of percussion, in as far as it may or may not be distinguishable from other forces, is not unattainable. We can learn as much, and no more, concerning this, as concerning any other force; and we can contemplate that circumstance which, in our opinion, is common to it with all other forces, and may perhaps discover other circumstances in which it differs from them. But in all this disquisition, it is plain that it is only events, which we conceive to be the characteristic effects of the cause, that we contemplate.

Percussion, considered as an effect, characteristic of a particular faculty of moving bodies, became an object of anxious research, almost as soon as philosophers began to think of motion and moving forces at all. The ancients (as has been observed in the article Impulsion, *Suppl.*) contented themselves with very vague speculations on the subject. Galileo was the first who considered it as a measurable thing, the object of mathematical discussion; being encouraged by his precious discovery of the laws of accelerated motion, and the very refined measure which these gave him of the power of gravity. It was a measure of the heaviness, not of the weight, of the body; and this was measured by its acceleration, and not by its pressure. Encouraged by this, he hoped to find some such measure of the force of percussion, which he saw so intimately connected with motion; whereas its connection with pressure was far from being obvious. He therefore tried to convert the terms; and as he had found a measure of the pressure of gravity in the acceleration of motion, he endeavoured to find in pressure a measure of the force of percussion arising from this acceleration. He endeavoured to find the number of pounds, whose pressure is equal to the blow of a given body, moving with a given velocity. The velocity was known to him with great precision, by means of the height from which the ball must fall in order to acquire it. It seems pretty clear that percussion may be measured in this way; for a body falling from a height will pierce an uniformly tenacious body to a certain degree, and no further; and experiment shews that this degree of penetration is very precise and constant. The same body, being merely laid on the tenacious body, will penetrate to a small depth by its weight. Laying more weight on it, will make it penetrate deeper; and a certain weight will make it penetrate as deep as the fall did, and no deeper. Thus, percussion seems very easily measurable by weight, or by any pressure similar to that of weight. It appears that Galileo made experiments with this view, and that he was disappointed, and obliged to acquiesce in the opinion of Aristotle, that percussion and weight are incomparable. He proposes, therefore, another experiment, namely, to drop a body into the scale of a balance from greater and greater heights, till at last the blow on the scale raises a weight that lies in the other scale. This offers itself so plausibly, that we are persuaded that Galileo tried it: but as he makes no men-

 tion

Percussion. tion of the results, we presume that they were unsatisfactory.

Neither of these experiments *could* give us a measure of the force of percussion, if this force be any thing different from the forces which are excited or brought into action by percussion, in the manner described in the article IMPULSION, *Suppl.* When the ball comes into physical contact with the scale, it begins to compress it. This compression begins to stretch the strings by which the scale is supported. These pull at the arm of the balance, and cause it to press the centre-pin a little harder on its support, and to bend the balance a little, and cause it to pull at the cords which support the other scale. That scale is pulled upwards, diminishing a little its pressure on the ground, and pressing it harder to the incumbent weight. These forces are excited *in succession* from the one scale to the other, and a small moment of time elapses. The reaction of the scale diminishes, but does not instantaneously annihilate, the velocity of the falling ball. It therefore compresses the scale still more, stretches the threads, presses the fulcrum, and bends the balance still more (because the weight in the other scale keeps it down). The velocity of the falling ball is rapidly diminished; the balance is more bent, and pulls more strongly upwards at the threads of the other scale; and thus presses that scale more strongly against the incumbent weight, gradually communicating more and more motion to it, removing it farther from the ground, till, at last, the motion becomes sensible, or so considerable as to disengage some delicate catch as a signal. The experiment is now finished; and the mechanician fondly thinks that, at this instant, the pressure excited by the percussion, between the opposite scale and the under side of the incumbent weight, is just equal, or but a very little superior, to the pressure of the incumbent weight: and, since the arms of the balance are equal, and therefore the pressures on the two scales are equal, he imagines that that weight exerts a pressure equal to the percussion of the falling ball.

But all this is misconception, and also false reasoning. It is not percussion that we are measuring, but the pressures, excited by percussion, on the two scales. And these pressures are the forces of elasticity or expansiveness, belonging to, or inherent in, the particles of the balls and the scales; forces which are brought into action by the approach of those bodies to each other. This reasoning is also erroneous; and we should be mistaken if we think that the pressure actually exerted is equal to that of the weight in the opposite scale. It is greater than the mere pressure of that weight. The reaction of the opposite scale on its load was precisely equal to that weight before the ball was dropped from the hand; and, had the ball been equal to that weight, and simply laid into the scale on which it falls, it would have made no change on the mutual pressures of the scale and the other weight; it would only have relieved the ground from the pressure of that weight, and would have brought it on the threads which support its scale. The pressure of this scale upwards must be increased, before it can start the weight sensibly from the ground. How much it must be increased depends on the springiness of the scales, cords, and beam. By a proper adjustment of these particulars, the apparatus will give us almost any measure of percussion that we choose. For this reason, the improvements made on it by Gravesande are of no value. The same reasoning, nearly, may be applied to the measurements of the force of percussion by means of the penetration of soft bodies. Percussion.

Galileo mentions another very curious experiment, by which he thought that he had obtained a just measure of percussion. A vessel, filled with water, was suspended on the arm of a balance, with another vessel hanging from it, a great way below. All was exactly balanced by a weight in the opposite scale. By means of a suitable contrivance, a hole was opened in the bottom of the upper vessel, without disturbing the equilibrium. As soon as the water issued, and while it was falling through the air, that end of the balance rose; but when the water struck the lower vessel, the equilibrium was restored, and continued during the whole time of the efflux. Hence Galileo concluded, that the force of the stroke was equal to the weight of the falling water. But we apprehend that the observations made on this in the article IMPULSION, *Suppl.* will convince the reader that this conclusion is far from being legitimate. Besides, the stroke, in any one instant, is made by those particles only which strike in that instant, while the whole vein of water between the vessels is neither acting by its weight on the upper vessel, nor by its stroke on the lower; and we should conclude from the experiment, that the force of percussion is infinitely greater than the weight of the striking body. Indeed this is the inference made by Galileo. But if we have recourse to the experiments and reasonings of Daniel Bernoulli, in the article *RESISTANCE of Fluids*, *Encycl.* we shall find that the seeming impulse on the lower vessel is really a most complicated pure pressure, and of most uncertain determination. The experiment is valuable, and gives room for curious reflections. We have repeated it, in a great variety of forms, and with great changes of impulse, and sometimes in such a manner that no impulse whatever can obtain, while at the same time a quantity of water was falling, unsupported by either vessel. In all the trials the equilibrium remained undisturbed. We were obliged to conclude, therefore, that the experiment afforded no measure of percussion. Indeed we were of this opinion before making the trial, for the reasons just now given.

We cannot say that the subsequent labours of philosophers have added much to our knowledge of this matter. Mr Leibnitz had contrived his whimsical doctrine of *living* and *dead* forces. The action of gravity, or of a spring, is a *vis viva*, when it actually produces motion in the body on which it acts: but when a stone lies on a table, and presses on it, this pressure is a *vis mortua*. Its exertion is made, and in the same instant destroyed, by an opposite *vis mortua*. Each of these exertions would have produced *a beginning* of motion (something different from any the smallest local motion); and the sum of all would, after a certain time, have amounted to a sensible motion and velocity. There seems no distinct conception to accompany, or that can accompany, this language. And, as a proof that Leibnitz had no distinct conceptions of the matter, he has recourse to this very experiment of Galileo in support of his genesis of a sensible motion from the continual exertions of the *vis mortua*; and he concludes that the force of percussion is infinitely, or incomparably, greater than pressure, because it is the sum total of an infinity of individual

dual exertions of *vis mortua*. Nothing but the authority which Leibnitz has acquired on the continent, by the zealous efforts of his partizans, could excuſe our taking up any time in conſidering this unintelligible diſcourſe. Surely, if there is ſuch a thing as a *vis viva*, it exiſts in the moving water, and its impulſions are not continual exertions of a *vis mortua*. Nor is it poſſible to conceive continual impulſe, nor a beginning of motion that is not motion, &c. &c. It is paradoxical (and Leibnitz loved to raiſe the wonder of his followers by paradoxes) to ſay that percuſſion is infinitely greater than preſſure, when we ſee that preſſure can do every thing that can be done by percuſſion. Nay, Euler, by far the moſt able ſupporter of the doctrines of Leibnitz about the force of bodies in motion, actually compares theſe two forces; and, in his Commentary on Robins's Artillery, demonſtrates, in his way, that when a muſket ball, moving with the velocity of 1700 feet per ſecond, penetrates five inches into a block of elm, the force of its percuſſion is [illegible]760 times its weight. John Bernoulli reſtricts the infinite magnitude of percuſſion to the caſe of perfectly hard bodies; and, for this reaſon alone, ſays, that there can be none ſuch in the univerſe. But, as this juſtly celebrated mathematician ſcouts with ſcorn the notion of attractions and repulſions, he muſt allow, that an ultimate atom of matter is unchangeable in its form; which we take to be ſynonymous with ſaying that it is perfectly hard. What muſt be the reſult of one atom in motion hitting another at reſt? Here muſt be an inſtantaneous production of a finite velocity, and an infinite percuſſion. A doctrine which reduces its abettors to ſuch ſubterfuges, [illegible] the mind in ſuch puzzling contemplations, cannot (to ſay the beſt of it) be ſtyled an EXPLANATION of the laws of Nature. The whole language on the ſubject is full of paradoxes and obſcurities. In order to reconcile this infinite magnitude of percuſſion with the obſerved finite magnitude of its effects, they ſay that the preſſure, or inſtantaneous effort, has the ſame relation to the force of percuſſion that an element has to its integral; and in maintaining this aſſertion, they continually conſider this integral under the expreſs denomination of a *ſum total*, robbing Leibnitz's great diſcovery of the infiniteſimal calculus of every ſuperiority that it poſſeſſed over Wallis's Arithmetic of Infinites, and really employing all the erroneous practices of the method of indiviſibles. We look upon the ſtrange things which have been inculcated, with pertinacious zeal, in this doctrine of percuſſion and *vires vivæ*, as the moſt remarkable example of the errors into which the unguarded uſe of Cavalerius's Indiviſibles, and of the Leibnitzian notion of the infiniteſimal calculus, have led eminent mathematicians. It is not true that the preſſure, and the ultimate force of percuſſion, have this relation; nor has the preſſure and the reſulting motion, which is miſtaken for the meaſure of this ultimate force, any mathematical relation whatever. The relation is purely phyſical; it is the relation of pure cauſe and effect; and all that we know of it is their conſtant conjunction. The relation of fluxion and fluent is not a mathematical or meaſurable relation, but a connection in thought; which is ſufficient for making the one an indication of the other, and the meaſures of the proportions of the one a mean for obtaining a meaſure of the proportions of the other. In this point of view, the relation of preſſure to motion, as the meaſure of the force of percuſſion, *reſembles* that of fluxion and fluent, but is not the ſame. Percuſſion.

Much has been ſaid by the partizans of Mr Leibnitz about the incomparableneſs of preſſure and percuſſion, and many experimental proofs have been adduced of the incomparable ſuperiority of the latter. Bulfinger ſays, that the preſſure of many tons will not cauſe a ſpike to penetrate a block of hard oak half ſo far as it may be driven by a weak man with [illegible] of a mallet; and that a moderate blow with a ſmall hammer will ſhiver to powder a diamond, which would carry a mountain without being hurt by its preſſure. Nay, even Mr Camus, of the Academy of Paris, a ſtaunch Carteſian, and an eminent mechanician, ſays that he beat a leaden bullet quite flat with a hammer of one pound weight, without much force; and that he found that 2[illegible] pounds weight would not have flattened it more than this blow: and he concludes from thence, that the force of the blow exceeded 200 pounds. Theſe, to be ſure, are remarkable facts, and juſtify a more minute conſideration of a power of producing certain effects, which is ſo frequently and ſo uſefully employed. But, at the ſame time, theſe are all very vague expr[illegible]s, and they do not authoriſe any preciſe concluſi[illegible] from them. Mr Camus ſaying "without much force," makes his pound weight, and his 200 pound weight, of no uſe [illegible] determining the force of the blow. He would have given more preciſe and applicable data for his deciſion, had he told us from what height the hammer ſhould fall in order to flatten the bullet to this degree. But even then we ſhould not have obtained any notion of the force in actual exertion during the flattening of the bullet; for the blow which could flatten the bullet in a longer or a ſhorter time, would unqueſtionably have been leſs or greater.

All the paradoxes, obſcurities, and puzzling difficulties, in this ſubject diſappear, if we leave out of our conſideration that unintelligible force, which is ſuppoſed to preſerve a body in motion or at reſt; and if we conſider both of theſe ſtates of body as conditions which will continue, unleſs ſome adequate cauſe operate a change; and if we farther grant, that ſuch cauſes do really exiſt in the univerſe, however unknown their nature may be by us; and, laſtly, if we acknowledge, that the phenomena of elaſticity, expanſiveneſs, coheſion, gravity, magnetiſm, electricity, are indications of the agency of ſuch cauſes, and that their actual exertions, and the motions and changes conſequent on theſe exertions, are ſo invariably connected with particular bodies, that they always accompany their appearance in certain mutual relations of diſtance and poſition:—if we proceed thus, all the phenomena of colliſion will be explained by theſe cauſes alone, without ſuppoſing the exiſtence and agency of a cauſe diſtinct from them all, and incomparable with them, called the FORCE OF PERCUSSION.

For it has been ſufficiently demonſtrated in the article IMPULSION (*Suppl.*), that that property of tangible coherent matter, which we call *perfect elaſticity*, operates as a preſſure during a certain ſmall portion of time on both bodies, diminiſhing more and more the motion of the one, and augmenting that of the other, as the compreſſion of one or both increaſes, till at laſt they ſeparate with ſenſible velocities. In ſome very ſimple or perſpicuous

 spicuous cases, we know what this pressure is in every instant of the action. We can tell how many pounds weight, at rest, will exert the same pressure. We can tell the whole duration of this pressure, and the space along which it is exerted; and, in such a case, we can say with precision what motion will be generated by this continued and varied pressure on the body which was at rest, and what diminution will be made in the motion of the other. All this can be done in the case of a ball A (fig. 1.), moving like a pendulum with a small velocity, and striking a slender elastic hoop B, also suspended like a pendulum. We can ascertain by experiment, before the collision, what pressure is necessary for compressing it one inch, one-half, one-fourth, &c. Knowing this, and the weight of the hoop, and the weight and velocity of the ball, we can tell every circumstance of the collision—how long the compression continues—what is the greatest compression—how far the bodies have moved while they were acting on each other—and what will be the final motion of each:—in short, every thing that affords any mark or measure of a force of percussion. And we know that all this is produced by a force, familiarly known to us by the name of elasticity. Which of all these circumstances shall be called the percussion, or the force of percussion? Is it the ultimate or greatest pressure occasioned by the compression? This cannot be, because this *alone* will not be proportional to the final change of motion, which is generally taken as a measure of the percussion when a change of motion is its only observed effect.

Plate XLI

We know that another perfectly elastic body, of the same weight, and struck by the same blow, and acquiring the same final velocity by the stroke, may not have sustained the tenth part of the pressure, in any one instant of the collision, if it has only been much more compressible. The greatest mutual pressure in the collision of a billiard ball is perhaps 1000 times greater than it is in a similar collision of a foot-ball of the same weight.

We also know what degree of compression will break this hoop, and what pressure will produce this compression. Therefore, should the fracture of the body be considered as the mark and measure of the percussion, we know what blow will just produce it, and be exhausted by so doing. In short, we know every mark and measure of percussion which this hoop can exhibit.

We can increase the strength of this hoop till it becomes a solid disk; and we see clearly, that in all these forms the mode of acting is the same. We see clearly that it is the same when, instead of the solid disk, it is an elastic ball; therefore every thing that can indicate or measure the percussion of an elastic ball, is explained without the operation of a peculiar force of percussion, even when the ball is shivered to pieces by the blow.

Nor is the case materially different when the bodies are soft, or imperfectly elastic. When the struck body is uniformly tenacious, it opposes a uniform resistance to penetration, and its motion will be uniformly accelerated by the action of its own tenacity during the whole time of mutual action, except a trifling variation occasioned by the mere motion of the internal parts, independent of their tenacity. If we knew the weight necessary for merely penetrating this mass, and the weight and velocity of the penetrating body, we can tell how long it must be resisted by this force before its initial velocity will be annihilated, and therefore how far it will penetrate. We have tried this with deal, birch, willow, and other soft woods of uniform texture, and with nails having the body somewhat slenderer than the end, that there might not be an irregularity occasioned by a friction on the sides of the nail, continually increasing as the penetration advanced. We made the hammer fall from a considerable height, and hit the nail with great accuracy in the direction of its length, by fixing it to the end of a long lath, moveable round an axis. The results corresponded with the calculation with all the precision that could be desired.

But it does not result from all this agreement, that the force, exertion, or effect, of a blow with a hammer is equal to the pressure of any number of pounds whatever. They are things that cannot be compared; and yet the force operating in the penetration by a blow is no way different from a pressure. It is a physical blunder to compare the ~~area of the curve~~, whose abscissa is the depth of penetration, and the ordinates are as the resistances, with any pressure whatever. This area expresses the square of a velocity, and its slips, bounded by parallel ordinates indefinitely near each other, are as the decrements of this square of a velocity, occasioned by a pressure, acting almost uniformly along a very small space, or during a very small time. It is an absurdity therefore to sum up these slips as so many pressures, and to consider the sum total as capable of expressing any weight whatever. Such a paralogism is peculiar to Leibnitz's way of conceiving his infinitesimal method, and it could have no place in the genuine method of fluxions. It is this misconception that has made Mr Leibnitz and his followers suppose that a body, accelerated by gravity, retains in it a sum total of all the pressures of gravity accumulated during its fall, and now forming a *vis viva*. Supposing that it requires a pressure of twenty pounds to press a six pound shot slowly through a mass of uniformly resisting clay; this pressure would carry it from the top to the bottom of a mountain of such clay. Yet this ball, if discharged horizontally from a cannon, would penetrate only a few yards, even though the clay should resist by tenacity only, independent of the motion lost by giving *motion* to its internal parts. In this experiment, the utmost pressure exerted during the motion of the ball did not much exceed the pressure of twenty pounds. In this comparison, therefore, percussion, so far from appearing infinitely greater than pressure, would appear much less. But there is perhaps no body that resists penetration with perfect uniformity, even though uniformly tenacious. When the ball has penetrated to some depth, the particles which are before it cannot be so easily displaced, even although they had no tenacity, because the particles adjoining are more hemmed in by those beyond them. We have always observed, that a ball impelled by gunpowder through water rises toward the surface (having entered horizontally through the side of the vessel at some depth), and this so much the more rapidly as it entered nearer to the surface. The reason is plain. The particles which must be displaced before the ball, escape more easily upwards than in any other direction. It is for this reason chiefly that a greater weight laid on the head of a nail will cause it sink deeper into the wood; and thus a great weight appears

to be commensurable with a great force of percussion. Also, while a bullet is flattening more and more under a hammer during the progress of a blow, it is spreading under the hammer; more particles are resisting at once, and they find more difficulty in effecting their escape, being harder squeezed between the hammer and the anvil. The same increased resistance must obtain while it is flattening more and more under the quiet pressure of a weight; and thus, too, a greater weight appears to be commensurable with a greater blow.

After all, however, a blow given by a falling body must excite a pressure greater than its mere weight can do, and this in any degree. Thus, suppose AB (fig. 2.) to represent a spiral spring in its natural unconstrained dimensions, standing upright on a table. Let $a\,b$ be the abscissa of a line $a\,d\,h\,k$, whose ordinates $c\,d$, $g\,h$, $i\,k$, &c. are as the elastic reaction of the spring when it is compressed into the lengths $c\,b$, $g\,b$, $i\,b$, &c. Suppose that, when it is compressed into the form CD, it will just support the weight of a ball lying on C. Then $c\,d$ will be a reaction equal to the weight of the ball, and the rectangle $a\,c\,d\,f$ will express the square of the velocity which this ball would acquire by falling freely through $a\,c$. If therefore the ball be gently laid on the top of the spring at A, and then let go, it will descend, compressing the spring. It will not stop when the spring has acquired the form CD, which enabled it to carry the weight of the ball gently laid on it. For in this situation it has acquired a velocity, of which the square is represented by the figure $a\,d\,f$ (See Dynamics, *Suppl.* n° 95.). It will compress the spring into the length $g\,b$, such that the area $c\,g\,h\,d$ is equal to the area $a\,d\,f$. If the ball, instead of being gently laid on A, be dropped from M, it will compress the spring into such a length $i\,b$, that the area $a\,i\,k$ is equal to the rectangle $m\,c\,d\,n$; and, if the spring cannot bear so great compression, it will be broken by this very moderate fall.

Thus we see that a blow may do things which a considerable pressure cannot accomplish. The accounts which are given of these remarkable effects of percussion, with the view of impressing notions of its great efficacy, are generally in very indefinite terms, and often without mentioning circumstances which are accessory to the effect. It would be very unfair to conclude an almost infinite power of percussion, from observing, that a particle of sand, dropped into a thick glass bottle which has not been annealed, will shiver it to pieces. When Mr Bulfinger says that a moderate blow will break a diamond which could carry a mountain, he not only says a thing of which he cannot demonstrate the truth, and which, in all probability, is not true; but he omits noticing a circumstance which he was mechanician enough to know would have a considerable share in the effect. We mean the rapidity with which the excited pressure increases to its maximum in the case of a blow. In the experiment in question, this happens in less than the millionth part of a second, if the velocity of the hammer has been such as a man would generate in it by a very moderate exertion. For the blow which will drive a good lath nail to the head in a piece of soft deal with an ordinary carpenter's hammer, must be accounted moderate. This we have learned by experiment to be above 25 feet per second. The connecting forces exerted between the particles of the diamond may not have time sufficient for their excitation in the remote parts, so as to share the derangement among them all, in such a manner that it may be so moderate in each as not to amount to a disunion in any part of the diamond. We see many instances of this in the abrupt handling of bodies of tender and friable texture. It is partly owing to this that a ball discharged from a pistol will go through a sheet of paper standing on edge without throwing it down, which it would certainly do if thrown at it by the hand. The connecting forces, having time to act in this last case, drag the other parts of the paper along with them, and their union is preserved. Also, when a great weight is laid on the diamond, it is gradually dimpled by it; and thus inclosing many parts together in the dimple, it obliges them to act in concert, and the derangement of each is thus diminished.

We flatter ourselves that the preceding observations and reflections will contribute somewhat towards removing the paradoxes and mysteries which discredit, in some degree, our mechanical science. If we will not pertinaciously conjure up ideal phantoms, which, perhaps, *cannot* exist, but content ourselves with the study of that tangible matter which the Author of Nature has presented to our view, we shall have abundant employment, and shall perceive a beautiful harmony thro' the whole of natural operations; and we shall gradually discover more and more of those mutual adaptations which enable an atom of matter, although of the same precise nature wherever it is found, to act such an unspeakable variety of parts, according to the diversity of its situations and the scene on which it is placed. If a mind be "not captivated by the harmony of such sweet sounds," we may pronounce it "dark as Erebus, and not to be trusted"

PERFECT Number, is one that is equal to the sum of all its aliquot parts when added together. Eucl. lib. 7, def. 22. As the number 6, which is $= 1 + 2 + 3$, the sum of all its aliquot parts; also 28, for $28 = 1 + 2 + 4 + 7 + 14$, the sum of all its aliquot parts. It is proved by Euclid, in the last prop. of book the 9th, that if the common geometrical series of numbers 1, 2, 4, 8, 16, 32, &c. be continued to such a number of terms, as that the sum of the said series of terms shall be a prime number, then the product of this sum by the last term of the series will be a perfect number.

PERGUNNA, in Bengal, the subdivision of a district.

PERKINISM, the proper name of what we must think an imposition attempted to be put upon the world by Dr Perkins of North America.

Though the phenomena of electricity had been long familiar to the philosophers of Europe, it is well known that a philosophical theory of these phenomena was first formed by a transatlantic philosopher. In like manner, though the discovery of Galvani, under the name of *animal electricity* (see Galvanism in this *Supplement*), had occupied the attention of many of the first physicians and philosophers of the old world, it was reserved for a physician of the new, to apply it to the cure of a number of diseases. Every philosopher of America, however, has not the sagacity of the Philadelphian sage; nor must Dr Perkins or his admirers be surprised, if we treat not incomprehensible mysticism with the respect due to a theory founded on facts.

Perkinism.

We are told by the son (A) of this rival of Franklin, that before the news of Galvani's discovery had reached America, he had observed several phenomena pointing out the influence of metals in cases of pain. The first remarkable incident that presented itself to his notice was the sudden contraction of a muscle when he was performing a chirurgical operation. This, he observed, regularly took place whenever the point of the metallic instrument was put in contact with the muscle. Struck with the *novelty* of the appearance (Is Mr Perkins sure that the appearance was new?), he was induced to try the points of wood and other substances; and no contraction taking place on these experiments, he thence inferred that the phenomena could be ascribed only to the influence of the metal. About the same time, he observed that, in one or two cases (and if his practice had been great he might have observed that in a thousand cases), a cessation of pain had ensued when a knife or lancet was applied to separate the gum from a tooth previous to extracting it; and in the same year he discovered, that *momentary* ease was given, in a few instances, by the accidental application of a metallic instrument to inflamed and painful tumors previous to any incision.

These are the judicious reasonings and assertions of a dutiful child, who, having probably heard of Leibnitz's claims to some of Newton's discoveries, was determined to put in a similar claim for his father, to a *share*, at least, of the discovery made by the celebrated professor at Bologna. He has not, however, copied with servility the conduct of the Leibnitzians. We do not remember an instance where any of them attempted to elevate the fame or the merits of their master *above* the fame and merits of Newton; but, according to our author, the pursuits of Galvani and his European pupils sink into insignificance, when compared with those of the transatlantic physician.

This is evident; for when the physiologists of Europe were engaged in experimenting on the denuded nerves and muscles of the smaller animals, with a view to ascertain the agency of this incomprehensible property in them, Dr Perkins was prosecuting a series of experiments, which consisted in applying externally, to parts affected with disease, metals, and compounds of metals of every description which occurred to him, and constructed into various forms and sizes. The result proved, that on drawing lightly over the parts affected certain instruments, termed *tractors*, which he formed from metallic substances into pointed shapes, he could remove most of those topical diseases of the human body, where an extra degree of nervous energy or vital heat was present; unless such disease was situated in some of the internal viscera, too remote from the part where the instruments could be applied.

The diseases which have been found most susceptible of the influence of the tractors are, rheumatism, some gouty affections, pleurisy, ophthalmias, erysipelas, violent spasmodic convulsions, as epileptic fits and the locked jaw, the pain and swelling attending contusions, inflammatory tumors, the [illegible] from a recent sprain, the painful effects of a burn or scald, pains in the head, teeth, and indeed most kinds of painful topical affections, excepting where the organic structure of the part is destroyed, as in wound[s,] ulcers, &c. and exc[epting] also where oils or some other non conducting substances are present.

But we have other testimonies than those of Dr Perkins and his son for the influence of the tractors. Mr Meigs, professor of natural philosophy at Newhaven, in a letter on Dr Perkins's discovery, conceives the principles of metallic irritability as so little understood, that he will not pretend to explain how the tractors produce their effects; but seems satisfied in finding that the effects are produced. After stating an experiment on his own child, eight years of age, very dangerously ill with a peripneumonic complaint, and to which the tractors gave almost instantaneous relief, he say[s], "I have used the tractors with success in several other cases in my own family; and although, like Naaman the Syrian, I cannot tell why the waters of Jordan should be better than Abana and Pharpar, rivers of Damascus; yet, since experien[ce] has proved them so, no reasoning can change the opinion. Indeed, the causes of all common facts are, *we think*, perfectly well known to us; and it is very probable, fifty or an hundred years hence, we shall as well know why the metallic tractors should in a few minutes remove violent pains, as we now know why cantharides and opium will produce opposite effects: viz. we shall know but *very little* about either, excepting *facts*."

Mr Woodward, professor of natural philosophy at Dartmouth, in a letter also on the same subject, has stated a number of successful experiments in pains of the head, face, teeth, and in one case of a sprain.

Dr Vaughan, a member of the Philadelphia medical society, has lately published an ingenious tract on Galvanism, the object of which is to account for the influence of the tractors in removing diseases. After a citation of numerous experiments made on the nerves and muscles of animals, he observes, "If we only take an impartial view of the operations of Nature herself, and attend diligently to the analytical investigations of the aforementioned experimentalists on this sublime subject, I think the sceptic must admit that the principle of nervous energy is a modification of electricity. As sensation is dependant on this energy, a pleasurable sensation, or what may be termed a natural or healthy degree thereof; then certainly pain, or supersensation, can only depend on an accumulation of the electric fluid, or extra degree of energy in the part affected. On this principle the problem admits of easy solution; namely, that the metals, being susceptible of this fluid, conduct the extra degree of energy to parts where it is diminished, or out of the system altogether, restoring the native law of electric equilibrium."

We trust we are not sceptics; and yet we feel not ourselves inclined to admit any part of this theory. We have seen no proof that nervous energy is a modification of electricity; and we think that we have ourselves proved, that *galvanism* and *electricity* are in many respects different; but we shall not be much surprised if we soon see a *demonstration* by some American or German philosopher,

(A) See a pamphlet, entitled The Influence of Metallic Tractors on the Human Body, &c. by Benjamin Douglas Perkins, A. M. son to the discoverer; or a very good abridgement of it in the first volume of the Philosophical Magazine.

rkinifm philofopher, that the foul of man is a compofition of filver and zinc. One of thefe fages has lately difcovered, that the fymptoms of *putrefaction* do not conftitute an *infallible* evidence of death, but that the application of *metals* will in all cafes afcertain it beyond the poffibility of doubt! A proper application certainly will; for when the Perkinift is doubtful whether his patient be dead or alive, he has only to apply the muzzle of a loaded piftol to his temple, and blow out his brains; after which he may fafely fwear that the man is dead.

From the *Philofophical Magazine*, we learn that Profeffor Schumacher at Copenhagen made experiments with tractors of brafs and iron on ten patients in Frederick's hofpital at Copenhagen. He tried alfo tractors of ebony and ivory, which are faid to have cured a pain in the knee; with others of filver and zinc; and fome of copper and lead. By the two laft, pains in the knee, arm, and face, are faid to have been mitigated. According to M. Klingberg's experiments, this remedy was of ufe in *malum ifchiaticum;* and according to thofe of M. Steffens, in *malum ifchiaticum* and megrim. According to M. Bang, the pains in fome cafes were increafed, and in others allayed. According to M. Blech, the tractors were of ufe in *hemicrania* and gouty pains in the head; and, according to M. Hahn, in rheumatic pains in both fhoulders. The principal

ifm, appears to be a letter of Profeffor Abilgaard, in whofe opinion Perkins's tractors will never acquire much value in medicine, and fcarcely even have the merit of being a palliative; but, in a phyfical point of view, he thinks they deferve the attention of phyficians, and particularly of phyfiologifts. Mankind (he fays) hitherto have paid too little attention to the influence which electricity has on the human body; otherwife they would know that the effects produced on it by our beds is no matter of indifference. If the feather beds and hair mattreffes, &c. are perfectly dry, the perfon who fleeps on them is in an infulated ftate; but the contrary is the cafe if they are moift. He three times removed a pain in the knee, by fticking the tractors, one on each fide of the knee, fo deep through the ftockings that the points touched the fkin. He removed a rheumatic pain in the head from a lady by the fame means. M. Kafn, by the tractors, relieved, in others, gouty pains of the head and megrim; and in himfelf, a rheumatic pain of the back, which, according to his fenfations, was like a conftriction in the cellular tiffue. M. Herholdt, from his experiments, confiders the effect of the tractors as indefinite and relative as that of other remedies. He, however, faw relief given by them in the ftrangury in a cafe of fyphilis. M. Bang alfo, at Soroe, freed a man from a violent gouty pain in the thigh, by drawing the tractors 200 times over the affected part. M. Jacobfen likewife found benefit derived from thefe tractors feveral times in the common hofpital at Copenhagen. M. Tode tried them alfo in rheumatic pains, tooth-ache, and inflammation of the eyes; and obferved that they neither did good nor harm.

On fome of the attefted cures mentioned in Mr Perkins's pamphlet, an able writer in the Monthly Review has made remarks fo very pertinent, that we cannot refufe ourfelves the pleafure of tranfcribing them.

" At page 54 of the pamphlet, we meet (fays the reviewer) with a ftrong proof of the confidence placed in this remedy by feveral tranfatlantic philofophers. Dr Willard, it feems, applied a red hot piece of iron to a wart on his finger, and burnt himfelf very feverely, in order that he might be relieved by the tractors; which are faid to have given him eafe in two fucceffive experiments. The author adds, 'many have fubmitted to fimilar meafures, in order to *experience* the effects. I once formed one of five, who burned ourfelves fo that blifters were raifed, to make the experiment; we all obtained relief in a few minutes.'

" This zeal for knowledge is truly edifying, efpecially as the tractors are generoufly prefented to the public at *only* five guineas a pair; and it is clear that one pair would fuffice to cure all the burns and fcalds of a large parifh. Why are not fuch luculent experiments repeated here? If Mr Perkins, or any admirers of the difcovery, would fubmit to have a red hot poker run into fome part of his body not neceffary to life (into *that part where honour's lodged*, according to Butler, for example), in any public coffee houfe within the bills of mortality, and would afterward heal the wound in prefence of the company, in ten minutes, or in half as many hours, by means of the tractors, the moft ftony-hearted infidel could not refift fuch a demonftration. Why trifle with internal inflammations, when fuch an outward and vifible fign might be afforded?

" Mr Perkins has taken fome pains, in the firft part of his pamphlet, to fhew that the operation of his rods is not derived from animal magnetifm. In our opinion, this is an unneceffary piece of trouble in England, where there is a conftant fucceffion of fimilar pretenfions. The *virgula divinatoria*, juggler, are the genuine prototypes of this myft... We were, indeed, rejoiced, on Dr Perkins's account, find that the Connecticut Society had only denounc... him as a Mefmerift: we trembled left he fhould have b... put into the inquifitorial hands of the old women a... white witch."

This may be thought too ludicrous a treatment of difcovery which profeffes to benefit mankind; but to have treated this difcovery with ferioufnefs, would have degraded the profeffion of a fcientific critic. As if the very cures pretended to have been performed did not of themfelves throw fufficient ridicule over the difcovery, Mr Perkins informs us, " that in fome inftances the metallic influence, when excited by different perfons, produces different effects. Experiments made to afcertain the point, proved that there were perfons who might ufe the tractors for any length of time, in difeafes which were fuitable for the operation, and produce no perceptible effect; when by placing them the hands of another perfon, who fhould perform the operation precifely in the fame manner as before, the pain or inflammation would be removed directly." Hence he endeavours to prove that the influence of the tractors is Galvanic, by an argument as abfurd as the pretended fact on which it is founded.

" On the application (fays he) of zinc and filver to the tongue, the fenfation of tafte is very flight to fome, while with others it is very ftrong:—when the experiment is applied to the fenfe of fight, fome are hardly fenfible of it, while others obferve a ftrong flafh." But, not to mention that neither ebony nor ivory can form part of the excitatory arc in *Galvanifm*, though we have

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have seen them both employed *successfully* as tractors by a Danish Perkinist, it is enough to observe, that the different effects of the Galvanic metals on different persons depend upon the difference of structure of the organs of sensation in the *patients*; whereas the different effects of the metallic tractors result, according to this account, from the difference of structure in the organs of sense of the various *operators!* Nay, what is still more extraordinary, if any thing can be more extraordinary than this, is, that the value of the tractors depends, not upon the *materials* of which they are made, or the *skill* of the manufacturer, but upon some inconceivable virtue conveyed by Mr Perkins to the *person* of him by whom they are *sold*. This we learn from a pamphlet published by Charles Cunningham Longworthy, surgeon in Bath; who informs us, that he sells tractors by *commission* from Mr Perkins the original manufacturer in London."

After this article was sent to the press, and thus much of it printed, we received, from a friend in London, a copy of Mr Perkins's last publication on the subject *; in which he endeavours to repel the objections urged by Dr Haygarth and others against the influence of the metallic tractors. Had we not been previously convinced of the falsity of Perkinism, the perusal of this pamphlet would have removed from our minds every doubt; for we will venture to say, that it is not in the power of Dr Haygarth, and the whole faculty united, to bring more complete proof than Mr Perkins has here brought, that what he calls his father's *discovery* has no claim to rank otherwise than with the discovery of Mesmer. See *Animal Magnetism*, Encycl.

* *The Eff- of Pe- Pa Meta &c. &c.*

He gives indeed 250 cases, which are attested to have been successfully treated by the tractors; but at least an equal number of cases were attested to have been successfully treated by Mesmer and his partisans; and six times that number of cures were said to have been miraculously performed at the tomb of the Abbé Paris (See Paris in this *Suppl.*) We would willingly allow, however, that these attestations ought to draw the attention of men of science to the subject, did not the author himself betray a want of confidence in the tractors, by his own arguments in their favour, and by his caution to the public against *counterfeits*. He seems indeed to consider their sanative influence as resulting entirely from his *patent*.

Dr Haygarth having said that he performed cures of the same kind with those of which Mr Perkins boasts, by the proper application of tractors made of *wood*; and having added, that "if any person would repeat these experiments, it should be done with due solemnity," in order to work upon the imagination; our author replies, by putting the following question: "Is there a single possessor of the *patent metallic* tractors in England who has frequently used them, and will say that this fraud is necessary to make *them* perform *cures?*" Instead of answering for the English possessors of these valuable instruments, we beg leave, in our turn, to ask, if there be a single expert chemist in Great Britain who can understand this question in any other sense, than as implying that the virtue of the tractors resides in the *patent?* This, however, appears still more palpable in the caution to the public.

"Among the various artifices (says Mr Perkins) which have been employed by certain interested persons, I have to mention the mean attempt to circulate *false tractors*, and from the failure of these to throw discredit upon the discovery. Three instances of this kind have occurred lately. Complaints having been made to me that my tractors would not cure the diseases for which they are recommended, I was led to make inquiry respecting the cases alluded to; and conceiving them fit subjects for the tractors, I called on the patients to apply them myself. In *both* instances (it was just now in *three* instances) I found they had been using *counterfeit* tractors. Had not this been discovered, the *merit* of the *patent* tractors must have suffered extremely!"

Perkinism, Perouse.

This is very extraordinary. The *character* or *fame* of any thing may indeed be injured by a counterfeit; but we believe this is the first instance of the *merit* or *demerit* of one inanimate substance being increased or diminished by another at a distance from it,--of the hardness of steel, for instance, being diminished by the softness of lead! But we beg Mr Perkins's pardon. The *merit* of his tractors consists in their putting money into his pocket; and *that* merit might certainly be injured by the use of *counterfeits*. Hence, with great propriety, he informs the public, that every *genuine set* is stamped with the words Perkins's patent tractors, accompanied with a receipt for the five guineas, numbered and signed in the handwriting of the patentee. From these facts we infer (and he must acknowledge the inference to be just), that the virtue of the tractors resides in the *patent*, restricting the making of them to *Benjamin Douglas Perkins*, and not to the *metal* of which they are made. This is indeed most obvious; for he cannot be such a stranger to the state of chemical science in this country, as to suppose that his tractors may not be analysed into their component principles, and, of course, that others may not be made possessing all their virtues except such as result from the patent.

We shall conclude this article in the words of the reviewer already quoted: "To trace the relations and dependencies of projects similar to that of Dr Perkins, would now be a work of more labour than utility. The fund of public credulity is an inexhaustible resource for those who can resolve to levy contributions on it. In vain is the spirit of quackery exorcised in one form; it rises again immediately, 'with twenty ghastly murders on its head, to push us from our stools.' We, who have contemplated the progress of real knowledge during a long course of years, have seen many bubbles like this glitter for a moment, and then disappear for ever. People may talk of Mesmerism, or Perkinism, but we consider all such varieties as belonging to the old and extensive class of Charlatanism."

PEROUSE (John Francis Galoup de la), the celebrated, though unfortunate, French navigator, was born at Albi in 1741. Of the rank or condition of his father, M *Milet-Mureau* has given us no information in that meagre eulogy of Perouse which he has inserted in the introduction to his last voyage. It appears, however, that he intended to make his son a seaman, and sent him, at a very early period of life, to the marine school, where the young man became enthusiastically fond of his profession, and laudably ambitious to emulate the fame of the most celebrated navigators.

Being

Being appointed a midshipman on the 19th of November 1756, he behaved, we are told, with great bravery in that station, and was severely wounded in the engagement between the admirals Hawke and Conflans, on the 20th of November 1759. The Formidable, in which he served, was taken, after a vigorous resistance; and it is probable that Perouse reaped some advantage from his acquaintance with British officers.

On the 1st of October 1764 he was promoted to the rank of lieutenant; and despising a life of ease and idleness, he contrived to be employed in six different ships of war during the peace that subsisted between Great Britain and France. In 1767 he was promoted to the rank of what, in our navy, is called *master* and *commander*. In 1779 he commanded the *Amazone*, belonging to the squadron of Vice admiral Count d'Estaing; and when that officer engaged Admiral Byron, the post of La Perouse was to carry his Admiral's orders to the whole of the line. He afterwards took the sloop *Ariel*, and contributed to the capture of the *Experiment*—exploits which his eulogist seems to consider as instances of very uncommon heroism; but he soon after performed a greater.

Being, on the 4th of April 1780, appointed captain of the frigate *Astrea*, and being on a cruise with the *Hermione*, these two frigates attacked six English vessels of war, of from 28 to 14 guns each, and took two of them. The French certainly reaped more laurels about that period than they have been accustomed to do in naval wars with Great Britain; but as we have completely forgotten the particulars of this fight, we suspect that it was not altogether so very brilliant a business as M. Milet-Mureau is pleased to represent it.

In the year 1782, La Perouse was dispatched with the Sceptre of 74 guns, and two frigates of 36 guns each, having some troops and field pieces on board, to destroy the English settlements in Hudson's Bay. This task was easily accomplished; for when he had surmounted the difficulties of navigation in a frozen sea, he found nothing on shore to oppose the smallest force. Having destroyed the settlements, he learned that some of the English had fled at his approach into the woods; and his eulogist considers it (such are the dispositions of French republicans) as a most wonderful instance of humanity, that he left to these unfortunate men provisions to preserve them from perishing by hunger, and arms to protect them from the fury of the savages! Perouse, we dare answer for him, was conscious of nothing heroic or extraordinary in this act of beneficence, which he certainly could not have omitted, without incurring both infamy and guilt.

In the year 1785, he was appointed to the command of a voyage round the world; which was unfortunately destined to be his last. Of this voyage, as far as it was accomplished, there is a full account in the hands of every French and English reader; and from that account it appears, that Perouse was admirably qualified to discharge such a trust. He seems to have been an experienced and skilful seaman; a man of considerable mathematical and physical science, uncorrupted by that philosophism which disgraced many of his attendants; and capable of the utmost perseverance in every laudable pursuit. To these qualities he united a proper combination of caution and courage, with a disposition truly benevolent to the various tribes of savages whom he visited. The disasters which occurred on the voyage were all, except the last, of which nothing is known, occasioned by the disobedience of his officers, or their neglecting to follow his advice.

The last dispatches of this great and good man were dated from Botany Bay, February the 7th 1788; and since that period, no account of him has been received which is intitled to the smallest confidence. *M. Milet-Mureau* has indeed given us, at some length, the childish conjectures of the Society of Natural History respecting his fate, which, in language equally childish, were delivered at the bar of the National Assembly; and he has added the ridiculous decree which that body of legislative sciolists passed in consequence of so extraordinary a speech. We will not disgrace our pages, or insult the memory of Perouse, by contributing to the circulation of nonsense, which, we are persuaded, would have made him blush for his country.

PERPENDICULAR, in gunnery, is a small instrument, used for finding the centre line of a piece in the operation of pointing it to a given object.

PERSIAN or PERSIC, in architecture, a name common to all statues of men, serving instead of columns to support entablatures.

PERWANNAH, in the language of Bengal, an order of government, or a letter from a person in authority.

PETERSBURGH (St), the capital of Russia, is a city, of which a pretty full historical detail has been given in the *Encyclopædia*. It is introduced here merely on account of its police, which, according to the anonymous author of the life of Catharine II. has a very simple and competent organization, and deserves to be adopted in other great capitals. Excepting the governor, whose office naturally extends to all objects of public welfare, the head police-master is the proper chief of the whole system of police. His office takes in the great compass of this department, but confined to the general objects of public security and order. He is not here, as in some large towns, the formidable copartner of family secrets, and the invisible witness of the actions of the private man. Under the head police-master is the police office, where sit a police master, two presidents, the one for criminal, the other for civil cases, and two consulters, chosen from the burgher class. To this is committed the care to maintain decorum, good order, and morals: also it is its business to see to the observance of the laws, that the orders issued by government, and the decisions of the courts of justice, are put in force. The attainment of these purposes is effected by the following mechanism:

The residence is divided into ten departments. Each of these has a president, appointed to watch over the laws, the security, and the order of his district. The duties and rights of this office are not less extensive than important. A president must have exact knowledge of the inhabitants of his department, over which a sort of parental authority is committed to him; he is the *censor morum* of his department; his house must not be bolted or barred by night or day, but must be a place of refuge, continually open to all that are in danger or distress; he himself may not quit the town for the space of two hours, without committing the discharge of his office to some other person. The police commando (constables), and the watchmen of his department, are

Peterſburgh.

under his orders; and he is attended on all affairs of his office by two ſerjeants. Complaints againſt unjuſt behaviour in the preſident may be brought to the police office.

Each department is again divided into three, four, or five ſubdiviſions, called quarters, of which, in the whole reſidence, are 42. Each of theſe has a quarter-inſpector, in ſubordination to whom is a quarter-lieutenant. The duty of theſe police-officers is in harmony with that of the preſident, only that their activity is confined to a ſmaller circle. They ſettle low affairs and ſlight altercations on the ſpot, and keep a watchful eye on all that paſſes.

The number of the nightly watch in the city amounts to 500. They have their ſtations aſſigned them in watch houſes at the corners of ſtreets; and, beſides their proper deſtination, are to aſſiſt in the taking up of offenders, and in any ſervice, by day or night, as their commanders ſhall require. Beſides theſe, for the execution of the police orders, and to act as patroles, there is alſo a commando of 120 men, who, in caſes of emergency, are ſupported by a company of koſaks, or a regiment of huſſars.

This machine, conſiſting of ſo many ſubordinate parts, preſerves in its orderly courſe that ſecurity and peace which excite the admiration of all foreigners. The activity of every individual member is unobſerved in the operation of the whole; and by ſuch a diſtribution alone is the attainment of ſo complicated an aim practicable.—All the quarter inſpectors of a department repair every morning, at ſeven o'clock, to their inſpector's houſe, to lay before him the report of all that has happened in their quarters during the laſt 24 hours; and at eight o'clock, all the inſpectors bring together theſe ſeveral reports into the police office, whereupon they ſit and immediately take into examination the caſes of perſons taken into cuſtody during the night. On urgent occaſions, the police office aſſembles at all hours.

This organization, and the extraordinary vigilance of the police, which is found competent to the buſineſs of a numerous and reſtleſs people, render all ſecret inquiſitions unneceſſary. The police has knowledge of all perſons in the reſidence; travellers who come and go are ſubject to certain formalities, which render it extremely difficult to conceal their place of abode, or their departure from the city. To this end, every houſeholder and innkeeper is obliged to declare to the police, who lodges with him, or what ſtrangers have put up at his houſe If a ſtranger or lodger ſtays out all night, the landlord muſt inform the police of it at lateſt on the third day of his abſence from his houſe. The cautionary rules, in regard to travellers quitting the town, are ſtill more ſtrict. Theſe muſt publiſh in the newſpapers their name, their quality, and their place of abode, three ſeveral times, and produce the newſpapers containing the advertiſement, as a credential in the government from which they then receive their paſſport; without which, it is next to impoſſible to get out of the empire. This regulation not only ſecures the creditor of the perſon about to depart, but alſo enables the police to keep a cloſer inſpection over all ſuſpected inhabitants.

If individuals may be ſuſpected by the government, becauſe their means of ſupport, the company they keep, and their whole courſe of action, are cloſely wrapped up in myſtery; ſo likewiſe may whole ſocieties be leſs indifferent to it, if they carefully conceal the object of their connection, or their very exiſtence, from the eye of the public. The police watches here, with laudable attention, over ſecret ſocieties of all kinds; and frequently as the fanatical ſpirit of religious or political ſectaries, or the enthuſiaſm of pretended myſtagogues, have attempted to neſtle here, they have never been able to proceed, or only for a very ſhort time. Animal magnetiſm, Martiniſm, Roſycrutianiſm, and by whatever other name the conceits of diſtempered imaginations may be called, have always been attended with the ſame bad ſucceſs on this ſtage.

From this ſketch it will be readily imagined, that the number of impoſtors and diſturbers of the public peace can be but ſmall. Quarrels and affrays in the ſtreet or in the cabaks but ſeldom happen. The perſon attacked calls the neareſt watchman; and in a moment both the aggreſſor and the aggrieved are taken into cuſtody, and led to the next ſieja (police-watch houſe), where the cauſe of their quarrel is inquired into, and the aggreſſor is puniſhed. For matters of ſome deſcriptions, there is a peculiar tribunal, under the denomination of the oral court, which, on account of its ſingularity, deſerves to be briefly noticed.

In each quarter of the town are one or more judges of the oral court, who are choſen from the claſs of burghers, and with whom are aſſociated a few jurats. This court ſits daily in the forenoon, and proceeds orally in all the differences that come before it. It, however, keeps a day-book, in which are entered all the cauſes and deciſions of the court, and which muſt be every week laid before the magiſtrate. When a charge is brought, the court declares it orally to the preſident of the quarter: whereupon the accuſed muſt not delay his appearance before the police longer than one day after he has received the ſummons. Every cauſe muſt be determined in one day, or, if the examinations require more time in collecting, in three days. The oral court communicates the deciſion to the preſident of the quarter by means of his day-book, in order to its ratification. If either party is not ſatisfied with the ſentence, he may appeal to the court as appointed in the regulations.

This is a very favourable account of the police of St Peterſburgh; but it is differently repreſented in *Beaujolin's Travels of two Frenchmen through Ruſſia*, in 1790—1792. According to him, the police of the capital of that empire is far from being on the moſt reſpectable footing. There happen, indeed, but few accidents in the night; yet ſometimes murders are committed, and eſpecially thefts; for which, according to our author, it is exceedingly rare to obtain juſtice. When a perſon has been aſſaſſinated in ſome place of bad repute, the police officer is engaged to ſecrecy by means of a few rubles; ſo that the affair is ſoon huſhed up, unleſs the deceaſed belonged to ſome powerful family, whoſe intereſt makes it neceſſary that inquiries ſhould be inſtituted. When two perſons quarrel, either in the ſtreet or in a public houſe, he who *pays* the inquirer is always in the right: the inferior police-officers are never proof againſt money; and the *poor* individual, whether he be in the right or wrong, is almoſt ſure of a beating.

PETIVER (James), a famous Engliſh botaniſt, was

Petiver, Phasianus.

contemporary with Plukenet; but the exact time of his birth is not known, nor is much intelligence concerning him at present to be obtained. His profession was that of an apothecary, to which he was apprenticed under Mr Feltham, then apothecary to St Bartholomew's hospital *. When he entered into business for himself, he settled in Aldersgate street, and there continued for the remainder of his life. He obtained considerable business, and after a time became apothecary to the charter house. After the Tradescants, he appears to have been the only person, except Mr Courten and Sir Hans Sloane, who made any considerable collection in natural history, previous to those of the present day. He engaged the captains and surgeons of ships to bring him home specimens, and enabled them to select proper objects, by printed directions which he distributed among them. By these means his collection became so valuable, that some time before his death, Sir Hans Sloane offered him L. 4000 for it. After his death, it was purchased by the some collector. His museum extended his fame both at home and abroad. He was elected into the Royal Society; and becoming acquainted with Ray, assisted him in arranging the second volume of his History of Plants. He died April 20. 1718: and much honour was shewn to him at his funeral, by the attendance of Sir Hans Sloane, and other eminent men, as pall bearers, &c. By future botanists, his name was given to a plant. See PETIVERIA, *Encycl.*

* Pulteney's *Sketches of Botany in England.*

He gave the world several publications on various subjects of natural history: 1. *Musei Petiveriani Centuria decem*, 1692—1703, 8vo. 2. *Gazophylacii Naturæ et Artis, Decades decem*, folio, 1702, with 100 plates. 3. A Catalogue of Mr Ray's English Herbal, illustrated with figures, folio, 1713, and continued in 1715. 4. Many small publications, which may be found enumerated in Dr Pultney's book. 5. Many papers in the Philosophical Transactions, and a material article in the third volume of Ray's work, entitled, *Plantæ Rariores Chinenses Madraspatanæ, et Africanæ, a Jacobo Petivero ad opus Consummandum Collatæ*, &c. Many of his smaller tracts having become very scarce, his works were collected and published, exclusive of his papers in the Transactions, in 2 vols folio, and one 8vo, in the year 1764.

PHASIANUS (See *Encycl.*). A species of this genus of birds, formerly not described, was sent from Batavia to England by Lord Macartney, or some of his attendants, when they were on their voyage to China. The species to which it seemed to be most nearly allied, in point of general habit or appearance, was the *phasianus curvirostris*, or Impeyan pheasant; an East Indian bird, described and figured both in Mr Latham's Ornithology, and in the Museum Leverianum. From that bird, however, it differs very considerably. The tail of the latter being in a mutilated state, it was scarce possible to determine, with absolute precision, whether it should be referred to that subdivision of pheasants, which contains those with long or cuneiform tails, or those with rounded ones, as in the Impeyan pheasant. The general colour of this most elegant bird was black, with a gloss of blue, or what, in the language of natural history, may be termed chalybean black, or black accompanied by a steel blue lustre. The lower part of the back was of a peculiarly rich colour, which, according to the different directions of the light, appeared either of a deep ferruginous or of the brightest fiery orange-red. This beautiful colour passed in the manner of a broad zone round the whole body, but on the abdomen was of a much more obscure appearance than on the back, as well as somewhat broken or irregular, especially on the sides. The throat was furnished with a large, and somewhat angular, pair of wattles, uniting with the bare spaces on the cheeks. The feathers on the top of the head, which was of a lengthened form, ran a little backward, so as to give the appearance of an indistinct occipital crest. The beak was remarkable for a more lengthened and curved aspect than in any other bird of this genus, except the Impeyan pheasant. The feathers on the neck, back, and breast, were rounded, and of the same shell-like or scaly habit as those of the turkey. The legs very stout, and were armed with a pair of extremely strong, large, and sharp spurs. Both legs and beak were of a pale colour. Whether this bird be really new or not to the ornithologists of Europe, it may at least be affirmed with safety, that it had never been properly described; nor can the character of any species, hitherto introduced into the books of any systematic naturalist, be considered as a just or competent specific character of the present bird. It may be called the *fire backed pheasant*; and its essential character may be delineated in the following terms: Black pheasant with a steel-blue gloss; the sides of the body rufous; the lower part of the back fiery ferruginous; the tail rounded; the two middle feathers pale yellow brown.—*Sir George Staunton's Account of an Embassy to China, &c.*

Phasianus, Philosophist, Ph

PHILOSOPHIST, a lover of sophistry or false reasoning, in contradistinction to *philosopher*, who is a lover of sound reasoning, true science, and practical wisdom.

CRITICAL PHILOSOPHY.

1 Origin of the science.

CRITICAL PHILOSOPHY, is the appellation given to a system of science, of which the founder is *Immanuel Kant*, regius professor of logic and metaphysics in the university of Koenigsberg. Of this system, which is very generally admired in Germany, we promised, in our Prospectus, to gratify our speculative readers with a short view; and that promise we are enabled to fulfil, by the kind communication of an illustrious foreigner, who, after acting a conspicuous part on the theatre of the world, and striving in vain to stem the torrent of democratic innovation, is now living an exile from his wretched country, and cultivating the sciences and the arts of peace.

2 Obscurity of its language.

"To explain (says he) the philosophy of Kant in all its details, would require a long and a painful study, without producing any real advantage to the reader. The language of the author is equally obscure, and his reasonings equally subtle, with those of the commentators of Aristotle in the 15th century."

The truth of this assertion will be denied by none, who

who have endeavoured to make themselves masters of the works of *Willich* and *Nitsch* on the critical philosophy; and the source of this obscurity seems to be sufficiently obvious. Besides employing a vast number of words of his own invention, derived from the Greek language, Kant uses expressions, which have long been familiar to metaphysicians, in a sense different from that in which they are generally received; and hence a large portion of time is requisite to enable the most sagacious mind to ascertain with precision the import of his phraseology.

The difficulty of comprehending this philosophy has contributed, we believe, more than any thing else, to bring it into vogue, and to raise the fame of its author. Men are ashamed, after so laborious and fatiguing a study, to acknowledge that all their labour has been thrown away; and vanity prompts almost every man to raise the importance of that branch of science which is understood but by a few, and in which he is conscious that his own attainments have been great. "We acknowledge, however, that in the system of Kant there is displayed much genius, combination, and systematic arrangement; but this only affords one of the many reasons which it presents, for our regretting that the author has not directed his mind to more useful researches, and that he has wasted the strength of his genius in rendering uncertain the most comfortable truths, and in giving the appearance of novelty to opinions for the most part taught long before his day.

The following analysis, we believe, will sufficiently enable any one, at all conversant with metaphysical science, to form a judgment of this celebrated system; and our correspondent, on whose word the reader may rely, assures us, that, in detailing the principles of Kant, he has taken special care to exhibit them with the utmost possible exactness, having several times preferred the obscurity of the author's reasonings and language, to the danger of a false, though more perspicuous, interpretation.

Division of human knowledge.

'Kant divides all our knowledge into that which is *a priori*, and that which is *a posteriori*. Knowledge *a priori* is conferred upon us by our nature. Knowledge *a posteriori* is derived from our sensations, or from experience; and is by our author denominated *empyric*. One would at first be induced, by this account of the origin of human knowledge, to believe that Kant intended to revive the system of *innate ideas*; but we very quickly discover that such is not his system. He considers all our knowledge as acquired. He maintains, that experience is the *occasional cause* or *productrice* of all our knowledge; and that without it we could not have a single idea. Our ideas *a priori*, he says, are produced *with* experience, and could not be produced *without* it; but they are not produced *by* it, or do not proceed *from* it. They exist in the mind; they are the *forms* of the mind. They are distinguished from other ideas by two marks, which are easily discerned; *i. e.* they appear *universal* and *necessary*; or, in other words, they admit of no exception, and their *converse* is impossible. Ideas which we derive from experience have no such characters. We can suppose, that what we have seen, or felt, or heard once, we may see, or feel, or hear again; but we do not perceive any impossibility in its being otherwise. For instance, a house is on fire in my view: I am certain of this fact; but it affords me no *general* or *necessary* knowledge. It is altogether *a posteriori*; the materials are furnished by the individual impression which I have received; and that impression might have been very different.

"But if I take twice two small balls, and learn to call twice two *four*, I shall be immediately convinced, that any two bodies whatever, when added to any two other bodies, will constantly make the sum of bodies *four*. Experience has indeed afforded me the *opportunity* of acquiring this knowledge; but it has not given it to me; for how could experience prove to me that this truth shall never vary? Experience must always be *limited*; and therefore cannot teach us that which is *necessary* and *universal*. It is not experience which discovers to us, that we shall always have the surface of the whole pyramid by multiplying its base by the third part of its height; or that two parallel lines, extended *in infinitum*, shall never meet.

"All the truths of pure mathematics are, in the language of Kant, *a priori*. Thus, that a straight line is the shortest of all possible lines between two fixed points; that the three angles of a triangle are always equal to two right angles; that we have the same sum, whether we add 5 to 7 or 7 to 5; and that we have the same remainder when we subtract 5 from 10 as when we subtract 10 from 15—are so many propositions, which are true *a priori*.

4 Pure knowledge *a priori*.

"Pure *knowledge a priori*, is that which is absolutely without any mixture of experience. *Two and two men make four men*, is a truth, of which the knowledge is *a priori*; but it is not PURE knowledge, because the truth is particular. The ideas of *substance*, and of *cause* and *effect*, are *a priori*; and when they are separated from the objects to which they refer (we suppose from this or that *particular* object), they form, in the language of Kant, *void ideas* (A). It is our knowledge *a priori*, *i. e.* that knowledge which precedes experience as to its origin, which renders experience possible (B). Our faculty of knowledge has an effect on our ideas of sensation analogous to that of a vessel, which gives its own form to the liquor with which it is filled. Thus, in all our knowledge *a posteriori*, there is something *a priori* derived from our faculty of knowledge. All the operations of our minds; all the impressions which our external and internal senses receive and retain, are brought into effect by the *conditions*, the *forms*, which exist in us by the pure ideas *a priori*, which alone render all our other knowledge certain.

5 Time and space.

"*Time* and *space* are the two essential forms of the mind:

(A) In the language of Locke *abstract ideas*.

(B) In our correspondent's manuscript, this sentence runs thus: "It is our knowledge *a priori*, or that knowledge which *entirely precedes experience* as to its origin, which experience renders possible;" but here must be some mistake, either by the translator or by the amanuensis. Kant's philosophy is abundantly obscure and paradoxical; but it surely never entered into his head to represent the effect as prior in its origin to the very cause which alone renders it possible. The context, too, seems to us to agree better with the meaning of the sentence as we have printed it in the text.

mind: the former for impressions received by the internal sense; the second for those received by our external senses. Time is necessary in all the *immediate* (perhaps *intuitive*) perceptions of objects; and space in all *external* perceptions.

6 Extension. "*Extension* is nothing real but as the form of our sensations. If extension were known to us only by experience, it would then be possible to conceive that there might be sensible objects without space.

7 Impenetrability, &c. "It is by means of the form *space* that we are enabled, *a priori*, to attribute to external objects *impenetrability*, *divisibility*, *mobility*, &c.; and it is by means of the form *time* that we attribute to any thing *duration*, *succession*, *simultaneity*, *permanence*, &c.

Origin of arithmetic and geometry. "*Arithmetic* is derived from the form of our internal sense, and *geometry* from that of our external.

9 Unifying power of the mind. "Our understanding collects the ideas received by the impressions made on our organs of sense, confers on these ideas *unity* by a particular *force* (we suppose energy) *a priori*; and thereby forms the representation of each object. Thus, a man is successively struck with the impressions of all the parts which form a particular garden. His understanding unites these impressions, or the ideas resulting from them; and in the unity produced by that unifying act, it acquires the idea of the garden. If the objects which produce the impressions afford also the *matter* of the ideas (c), then the ideas are *empyric*; but if the objects only unfold the *forms of the thought*, the ideas are *a priori*. The act of the understanding which unites the perceptions of the various parts of an object into the perception of one whole, is the same with that which unites the attribute with its subject.

10 Analytic judgments. "Judgments are divided into two species; *analytic* and *synthetic*. An analytic judgment is that in which the attribute is the mere developement of the subject, and is found by the simple analysis of the perception; as *bodies are extended*; *a triangle has three sides*.

11 Synthetic judgments. "A synthetical judgment is that where the attribute is connected with the subject by a cause (or basis) taken from the faculty of knowledge, which renders this connection necessary: as, *a body is heavy*; *wood is combustible*; *the three angles of a triangle are equal to two right angles*. There are syntheses *a priori* and *a posteriori*; and the former being formed by experience, we have the sure means of avoiding deception.

It is a problem, however, of the utmost importance, to discover how synthetic judgments *a priori* are possible. How comes it, for example, that we can affirm that all the radii of a circle are equal, and that two parallel lines will never meet? It is by studying the *forms* of our mind that we discover the possibility of making these affirmations. In all objects there are things which must necessarily be THOUGHT (be supplied by thought); as, for example, that there is *a substance*, an *accident*, a *cause*, and certain *effects*.

12 Forms of the understanding. "The *forms* of the understanding are, *quantity*, *quality*, *relation*, *modality*.

"Quantity, Kant distinguishes into *general*, *particular*, and *individual*; quality, into *affirmation*, *negation*, *infinite*; relation, into *categoric*, *hypothetic*, and *disjunctive*; and modality, into *problematic*, *certain*, and *necessary*. He adds also to these properties of the four principal forms of the understanding, a table of *categories*, or fundamental ideas *a priori*.

"Quantity, gives *unity*, *plurality*, *totality*. Quality, gives *reality*, *negation*, *limitation*. Relation, gives *inherence*, *substance*, *cause*, *dependence*, *community*, *reciprocity*. Modality, gives *possibility*, *impossibility*, *existence*, *nothing*, *necessity*, *accident*. These categories can only be applied to experience. When, in the consideration of an object, we abstract all that regards sensation, there remain only the pure ideas of the understanding, or the *categories*, by which a *thing* is conceived as a *thing*. 13 Categories.

"Pure reason is the faculty of tracing our knowledge *a priori*, to subject it to principles, to trace it from its necessary conditions, till it be entirely without condition, and in complete unity. This pure reason has certain fundamental rules, after which the necessary connection of our ideas is taken for the determination of the objects in themselves;—an illusion which we cannot avoid, even when we are acquainted with it. We can conclude from what we know to what we do not know; and we give an *objective* reality to these conclusions from *an appearance* which leads us on.

"The writings of Kant are multifarious; but it is in his work entitled the *Critique of Pure Reason* that he has chiefly expounded his system. This work is a treatise on a pretended science, of which Kant's scholars consider him as the founder, and which has for its objects the *natural forces*, the *limits of our reason*, as the source of our pure knowledge *a priori*, the *principles of all truth*. Kant does not propose to give even an exposition of these branches of knowledge, but merely to examine their origin; not to extend them, but to prevent the bad use of them, and to guard us against error. He denominates this science *transcendental criticism*; because he calls all knowledge, of which the object is not furnished by the senses, and which concerns the kind and origin of our ideas, *transcendental knowledge*. The Criticism of Pure Reason, which gives only the fundamental ideas and maxims *a priori*, without explaining the ideas which are derived from them, can lead (says Kant) to a complete system of pure knowledge, which ought to be denominated *transcendental philosophy*, of which it (the *Criticism*, &c.) presents the *architectonic* plan, *i. e.* the plan regular and well disposed. 14 Critique of pure reason.

"The work entitled *The Critique of Pure Reason*, is divided into several parts or sections, under the ridiculous titles of *Æsthetic transcendental*; of *transcendental logic*; of *the pure ideas of the understanding*; of *the transcendental judgment*; of *the paralogism of pure reason*; of *the ideal transcendental*; of *the criticism of speculative theologies*; of *the discipline of pure reason*, &c.

"But to proceed with our abstract of the system. We know objects only by the manner in which they affect us; and as the impressions which they make upon us are only certain *apparitions* or *phenomena*, it is impossible for us to know what an *object is in itself*. 15 We cannot know objects as they are in themselves.
consequence of this assertion, some have supposed that Kant is an *idealist* like Berkeley and so many others, who have thought that sensations are only *appearances*, and

(c) This is wonderful jargon; but the reader will reflect that it is not o

and that there is no truth but in our reason; but such is not the opinion of Kant (D). According to him, our understanding, when it considers the apparitions or phenomena, acknowledges the *existence* of the objects in themselves, inasmuch as they serve for the bases of those apparitions; though we know nothing of their *reality*, and though we can have no certitude but in experience.

"When we apply the *forms* of our understanding, such as *unity*, *totality*, *substance*, *causality*, *existence*, to certain ideas which have no object in *space* and *time*, we make a fallacious and arbitrary application. All these forms can bear only on sensible objects, and not on the *world of things in itself*, of which we can THINK, but which we CAN NEVER KNOW. Beyond things sensible we can only have *opinions* or a *belief* of our reason.

16 Objective and subjective truths. "The motives to consider a proposition as true, are either *objective*, *i. e.* taken from an *external* object, so that each man shall be obliged to acknowledge them; and then there is a truth *evident* and susceptible of *demonstration*, and it may be said that we are *convinced*; or the motives are *subjective*, *i. e.* they exist only in the mind of him who judges, and he is *persuaded*.

"TRUTH, then, consists in the agreement of our *notions* with the *objects*, in such a manner as that all men are obliged to form the same judgment; BELIEF consists in holding a thing for true in a *subjective manner*, in consequence of a persuasion which is entirely personal, and has not its basis in an object submitted to experience.

17 Belief. "There is a *belief of doctrine*, of which Kant gives, as an example, this assertion—'there are inhabitants in the planets.' We must acknowledge (he adds) that the ordinary mode of teaching the existence of God belongs to *the belief of doctrine*, and that it is the same with *the immortality of the soul*. *The belief of doctrine* (he continues) has in itself something *staggering*; but it is not the same with *moral belief*. In moral belief there is something *necessary*; it is (says he), that I should obey the law of morality in all its parts. The end is strongly established; and I can perceive only one condition, by means of which this end may be in accord with all the other ends, *i. e.* that *there is a God*. I am certain that no man knows any other condition which can conduct to the same unity of end under the moral law; which law is a law of my reason. I will consequently believe certainly the *existence of God*, and a *future life*; because this persuasion renders immoveable my moral

18 Proof of the existence of God, &c. principles—principles which I cannot reject without rendering myself contemptible in my own eyes. I wish for happiness, but I do not wish for it without morality; and as it depends on *nature*, I cannot wish it with this condition, except by believing that nature depends on a Being who causes this connection between morality and happiness. This supposition is founded on the *want* (or *necessity*) of my reason, and not on my duty.

"We have, however, no *certainty* (says Kant) in our knowledge of God, because certainty cannot exist except when it is founded on an object of experience. The philosopher acknowledges, that *pure reason* is too weak to prove the existence of a being beyond the reach of our senses. The necessity of believing in God is therefore only *subjective*, although necessary and general for all those beings who conform to their duty. This is not *knowledge*, but only a *belief* of reason, which supplies the place of a knowledge which is impossible (E).

"The proofs of natural theology (says our philosopher) taken from the order and beauty of the universe, &c. are proofs only in *appearance*. They resolve themselves into a bias of our reason to *suppose* an Infinite Intelligence as the author of all that is possible; but from this bias it does not follow that there really is such an Author. To say, that whatever exists must have a cause, is indeed a maxim *a priori*; but it is a maxim applicable only to experience, for one knows not how to subject to the laws of our perceptions that which is absolutely independent of them. It is as if we were to say, that whatever exists in experience must have an experience; but the world, taken as a whole, is without experience as well as its cause. It is much better to draw the proof of the existence of God from morality, than to weaken it by such reasoning. This proof is relative. It is impossible to *know* that God exists; but we can comprehend how it is possible to act morally on the *supposition* of the existence (although incomprehensible) of an intelligent Creator—an existence which PRACTICAL REASON forces THEORETICAL *reason* to adopt. This proof not only *persuades*, but even acts on the CONVICTION, in proportion as the motives of our actions are conformable to the law of morality.

"Religion ought to be the *means* of virtue and not its object. Man has not in himself the idea of religion as he has that of virtue. The latter has its principle in the mind; it exists in itself, and not as the means of happiness; and it may be taught without the idea of a God, for the pure law of morality is *a priori*.

"He who does good by inclination does not act *morally*. The converse of the principle of morality is to make personal happiness the basis (F) of the will. 19 Morality. There are compassionate minds which feel an internal pleasure in communicating joy around them, and who thus enjoy the satisfaction of others; but their actions, however just, however good, have no moral merit, and may be compared to other inclinations; to that of honour

(D) We must request the reader to observe that this is the language of our correspondent. We have shewn elsewhere, that Berkeley did not deny the reality of sensations; and we hope to shew by and bye, that Kant is as much an *idealist* as he was, if this be a fair view of the Critical Philosophy.

(E) We have here again taken the liberty to alter the language of our correspondent. He makes Kant say, "It is not this knowledge, but a *belief* of reason, &c.;" but this is surely not the author's meaning. From the context, it is apparent that Kant means to say, that we have not, and cannot have, what can be properly called a *knowledge* of the existence of God, but only such a belief of his existence as supplies the place of this impossible knowledge.

(F) This is a very absurd phrase. We suppose Kant's meaning to be, that the principles of him whose actions and volitions are influenced by the prospect of personal happiness, are the reverse of the pure principles of morality.

honour (for example), which, whilst it meets with that which is just and useful, is worthy of praise and encouragement, but not of any high degree of esteem. According to Kant, we ought not even to *do good*, either for the pleasure we feel in doing it, or in order to be happy, or to render others happy; for any one of these additions (perhaps motives) would be *empyric*, and injure the purity of our morals. A reasonable being ought to desire to be exempted from all *inclinations*, and never to do his duty but for his duty's sake.

"We ought to act after the maxims derived *a priori* from the faculty of knowledge, which carry with them the idea of necessity, and are independent of all experience; after the maxims which, it is to be wished, could be erected into GENERAL LAWS for all beings endowed with reason."

20 Futility of this system.

If this be a correct view of the object and the results of the critical philosophy, and the character of him from whom we received it permits us not to doubt of its being nearly correct, we confess ourselves unable to discover any motive which should induce our countrymen, in their researches after truth, to prefer the dark lantern of Kant to the luminous torch of Bacon. The metaphysical reader will perceive, that, in this abstract, there is little which is new except the phraseology; and that what is new is either unintelligible or untenable.

21 Of which the fundamental principles are not new.

The distinction between knowledge *a priori* and knowledge *a posteriori*, is as old as speculation itself; and the mode in which Kant illustrates that distinction differs not from the illustrations of Aristotle on the same subject. The Stagyrite talked of *general forms*, or *formal causes*, in the mind, as well as the professor at Koenigsberg; and he or his disciples (for we quote from memory) compared them to the form of the statue in the rough block of marble. As that form is brought into the view of the spectator by the chissel of the statuary, so, said the peripatetics, are the general *forms* in the mind brought into the view of consciousness by sensation and experience.

Such was the doctrine of Aristotle and his disciples, and such seems to be the doctrine of Kant and his followers; but it is either a false doctrine, or, if it be true, a doctrine foolishly expressed. A block of marble is capable of being cut into any form that the statuary pleases; into the form of a man, a horse, an ox, an ass, a fish, or a serpent. Not one of these forms therefore can be inherent in it, or essential to it, in opposition to the rest; and a general form, including all the animals under it, is inconceivable and impossible. In like manner, the human mind is capable of having the ideas of a circle, a triangle, a square, of black, white, red, of four, sweet, bitter, of the odour of a rose, and the stench of a dunghill, of proportion, of musical sounds, and of a thousand other things. None of these ideas therefore can be essential to the mind in opposition to the rest; and every man, who is not an absolute stranger to the operations of his own intellect, knows well that he cannot think of a thousand things at once; or, to use the language of philosophers, have in his mind a general idea, comprehending under it a thousand things so discordant as colours and sounds, figures, and smells. If therefore Kant means to affirm, with Plato, that, previous to all experience, there are *actually* in the mind *general forms*, or *general ideas*, to which sensation, or experience, gives an opportunity of coming into view, he affirms what all men of reflection know to be false. If he means only to affirm, what seems to have been the meaning of Aristotle, that particular sensations give occasion to the intellect to form general ideas, he expresses himself indeed very strangely; but his doctrine on this subject differs not essentially from that of Locke and Reid, and many other eminent metaphysicians of modern times. Of abstraction and general ideas we have given our own opinion elsewhere (see METAPHYSICS, *Encycl.* Part I. Chap. iv.), and shall not here resume the subject.

22 Impropriety of term.

But when Kant says that his ideas *a priori* are *universal*, and *necessary*, and that their converse is *impossible*, he seems by the word *idea* to mean what more accurate writers express by the term *proposition*. There are indeed two kinds of propositions, of which both may be true, though the one kind expresses necessary and universal truths, and the other such truths as are contingent and particular. (See METAPHYSICS, *Encyc.* Part I. Chapter vii.) Propositions directly contrary to those which express particular and contingent truths may be easily conceived; whilst such as are contrary to necessary and universal truths are inconceivable and impossible; but we doubt whether *any idea*, in the proper sense of the word, has a *contrary* or, as he expresses it, a *converse*. *Nothing* is not contrary to *substance*, nor *black* contrary to *white*, nor *four* contrary to *sweet*, nor an *inch* contrary to an *ell*. Nothing is the negation of substance, and black the negation of white; four is different from sweet, and an inch is less than an ell; but between these different ideas we perceive no contradiction.

That Kant uses the term *idea* instead of *proposition*, or some word of similar import, is farther evident from his instances of *the house on fire*, and the manner in which we learn that any two bodies added to any two other bodies will constantly make the sum of *four bodies*. If it be his will to use the terms *a priori* and *a posteriori* in the sense in which other metaphysicians use the terms *necessary* and *contingent*, we can make no other objection to his distinction between these two propositions, but that it is expressed in very improper language. The house might certainly be *on fire* or *not* on fire; but twice two bodies *must* always make the sum of four bodies, and cannot possibly make any other sum.

The truth of this last proposition (he says) we cannot have learned from *experience*, because experience, being always limited, cannot possibly teach us what is *necessary* and *universal*. But this is egregious trifling. The experience employed here is not limited. A child unquestionably learns the import of the terms of numeration, as he learns the import of all other terms, by experience. By putting two little balls to two little balls, he learns to call the sum *four* balls. After two or three lessons of this kind with different bodies, his own reflection suggests to him, that the sum four has no dependance upon the shape or consistence of the bodies, but merely upon the *individuality* of each or their numerical difference; and individuality, or numerical difference, is as completely exemplified in two bodies of any kind as in two thousand.

23 With its consequences.

All the truths of pure mathematics (says Kant) are *a priori*. If he means that they are all *necessary*, and that the contrary of any one of them is *inconceivable*, he affirms nothing but what is true, and has been known

to

to all mathematicians these two thousand years. But, if he means that they are *innate* truths, not discovered by induction or ideal measurement, his meaning is demonstrably false. (See INDUCTION in this *Supplement.*) When he says, that it is not *experience* which discovers to us that we shall always have the surface of the pyramid, by multiplying its base by the third part of its height, he is right, if by experience he means the actual measurement of all possible pyramids; but surely he cannot mean that the truth of this measurement is innate in the mind, for it is in fact not a true but a false measurement (c). The base of a pyramid multiplied by the third part of its height gives, not the surface, but the solid contents of the pyramid; and he who understands the proposition on which this truth is immediately built, knows perfectly that Euclid proved it by a series of ideal measurements of those particulars in which all pyramids necessarily agree.

Kant seems often to confound sensation with experience; and if by experience he means *sensation*, when he says that *pure knowledge, a priori*, is that which is absolutely without any mixture of experience, he talks nonsense; for the most spiritual notions which men can form are derived from the operations of the mind on ideas of sensation. To the rest of the paragraph, respecting pure knowledge, we have hardly any objection to make. Locke, the great enemy of innate ideas, taught, before Kant was born, that our knowledge depends upon our organization and the faculties of our minds, as much as upon impressions made on the senses *ab extra*; that if our organs of sense were different from what they are, the taste of sugar might be bitter, and that of wormwood sweet; and that if we had not memory, and could not modify and arrange our ideas, all progress in knowledge would be impossible.

24 Groundless or false assertions. When our author talks of *time* and *space* as the two essential *forms* of the mind, we are not sure that we understand him. We have shewn elsewhere, that a conscious intelligence may be conceived which has no ideas either of space or of time (see METAPHYSICS, *Encycl.* n° 182, &c. and 209, &c.); and he who can affirm, that if extension were known to us only by *experience*, it would be possible to conceive sensible objects *without space*, has never attended to the force of what philosophers call *the association of ideas in the mind.* But what is here meant by sensible objects? Are they objects of touch, taste, or smell? Objects of touch cannot indeed be conceived without space; but what extent of space is suggested by the taste of sugar or the odour of a rose?

When Kant talks of the *form* space enabling us to attribute to external objects *impenetrability, mobility*, &c. he talks at random; and another man may, with as much propriety, and perhaps more truth, affirm the converse of his propositions, and say, that it is the impenetrability and mobility, &c. of external objects that enable us to form the idea called *space*, and the succession of some objects, compared with the permanence of others, that enables us to form the notion or mode called *time*.

On the two or three next paragraphs it is not worth while to detain the reader with many remarks. They abound with the same uncouth and obscure phraseology, and the same idle distinctions between ideas *a priori* and *a posteriori*. In n° 11. he affirms, that the three following propositions (*a body is heavy, wood is combustible*, and *the three angles of a triangle are equal to two right angles*) are all necessary judgments. 25 Bad logic. In one sense this affirmation is true, and in another it is false. We cannot, without speaking unintelligibly, give the name *body* to any substance which is not heavy; and we are not acquainted with any kind of *wood* which is not combustible; but surely it is not impossible to conceive a substance extended and divisible, and yet *not* heavy, to which the name *body* might be given without absurdity, or to conceive wood as incombustible as the mineral called *asbestos*. That the three angles, however, of a plane triangle can be either more or less than equal to two right angles, is obviously impossible, and must be perceived to be so by every intelligence from the Supreme down to the human. The three propositions, therefore, are not of the same kind, and should not have been classed under the same genus of *necessary* synthetic judgments.

In the critique of pure reason, Kant seems to teach that all demonstrative science must proceed from general principles to particular truths. Hence his *forms* of the understanding, and his *categories*, which, according to one of his pupils*, "lie in our understanding as pure notions *a priori*, or the foundation of all our knowledge. They are *necessary forms, radical* notions, of which all our knowledge *must* be compounded." But this is directly contrary to the progress of the human mind, which, as we have shewn in the article INDUCTION, already referred to, proceeds, in the acquisition of every kind of knowledge, from particular truths to general principles. This *transcendental philosophy* of Kant's, therefore, inverts the order of nature, and is as little calculated to promote the progress of science as the syllogistic system of Aristotle, which was likewise built on *categories* or *general forms*. His *transcendental esthetic*, which, according to Dr Willich, is the knowledge *a priori* of the *rules of sensation*, seems to be a contradictory expression, as it implies that a man may know the laws of sensation, without paying the smallest attention to the organs of sense.

* Dr Willich.

That we know objects only by the manner in which they affect us, and not as they are in themselves, is a truth admitted, we believe, by all philosophers, and certainly by Locke and Reid; but when Kant says that we know nothing of the *reality* of the objects which affect our senses, he seems to be singularly paradoxical. Berkeley himself, the most ingenious idealist perhaps that ever wrote, contends strenuously for the existence of a *cause* of our sensations distinct from our own minds; and because he thinks inert matter a cause inadequate

(c) This may look like cavilling, as the blunder may be either Kant's or our correspondent's, though neither of them can be supposed ignorant of the method of measuring the surface of a pyramid. We assure the reader, however, that we do not mean to cavil. We admit that both Kant and our correspondent know perfectly well how to measure the surface of a pyramid; but had that knowledge been *innate* in their minds, we cannot conceive the possibility of their falling into the blunder. The blunder, therefore, though the offspring of mere inadvertence, seems to be a complete confutation of the doctrine.

inadequate to this effect, he concludes, that every sensation of which we are conscious is a proof of the immediate agency of the Deity. But Kant, as we shall perceive by and bye, makes the existence of God and of matter equally problematical. Indeed he says expressly, that beyond things sensible we can only have *opinions* or *belief;* but things sensible, as every one knows, are nothing more than the *qualities* of objects.

26 Tendency of the system towards atheism.

It should seem that the greater number of wonders which Kant has found in our primitive knowledge and in the faculties of our mind, the greater number of proofs ought he to have found of the existence and attributes of one First Cause: but so far is this from being the case, that we have seen him resting the evidence of this most important of all truths, either upon the *moral sense,* which our passions and appetites so easily alter, or upon the intuitive perception of *abstract moral rectitude;* a perception which thousands, as virtuous and as profound as he, have considered as impossible. Our philosopher's proof of a God is nothing more than his persuasion that happiness is connected with virtue by a Being upon whom nature depends; and he says expressly, that this proof carries conviction to the mind in proportion as the motives of a man's actions are conformable to the law of morality. This being the case, the reader cannot be much surprised, when he is informed that several of Kant's disciples on the continent have avowed themselves Atheists or Spinozists. We have elsewhere (see ILLUMINATI, n° 37.) mentioned one of those gentlemen who was lately dismissed from his professorial chair in the university of Jena, for making GOD nothing more than an *abstract idea,* derived from our relations with the moral world. His successor, a Kantist likewise, when it was told in his presence, that, during one of the massacres in Paris, David the Painter sat with his pencil in his hand, enjoying the sufferings of the unfortunate wretches, and trying to paint the expressions of their agonies, exclaimed—"What force of character! What sublimity of soul!" That this wretch must be an Atheist, likewise, follows of course from Kant's principles; for it is not conceivable that he perceives any connection between happiness and virtue.

That Kant is an atheist himself, we have not learned, though his doctrine leads thus naturally to atheism, and though in his work called TUGEND LEHRE, page 180, he makes the following strange observation upon oaths: "As it would be absurd to swear that God exists, it is still a question to be determined, whether an oath would be possible and obligatory if one were to make it thus—*I swear on the supposition that God exists.* It is extremely probable (says he), that all *sincere* oaths, taken with *reflection,* have been taken in no other sense!"

It is not our intention to plunge deeper into this mire of atheism, or to enter into a formal confutation of the detestable doctrines which have been dragged from its bottom. Enough has been said elsewhere to convince the *theoretical* reason of the sound minds of our countrymen of the existence of one omnipotent, infinitely wise, and perfectly good Being, the author and upholder of all things (See *Encycl.* METAPHYSICS, Part III. Chap. vi. and THEOLOGY, Part I. Sect. 1.). It may not, however, be altogether useless to point out to the reader how completely Kant confutes himself, even in the short abstract that we have given of his system.

27 Kant confutes himself.

Among his *categories,* or fundamental ideas, which are *necessarily* formed in the mind, he expressly reckons *cause* and *effect:* but in various articles of this work, it has been proved beyond the possibility of contradiction, that no *sensible* object is the *true metaphysical cause* of any one event in nature; and indeed Kant himself is at much pains to shew that his *categories* or ideas *a priori* are not ideas of sensation. There must therefore, upon his own principles, be causes which are *not* the objects of *sense* or *experience;* and by tracing these causes backward, if there be a succession of them, we must arrive at one self-existent cause, by a demonstration as complete as that by which Euclid proves the equality of the three angles of a plane triangle to two right angles. We have no other evidence for the truth of geometrical axioms than the laws of human thought, which compel us to perceive the impossibility of such propositions being false. According to our philosopher, we have the very same evidence for the reality of causes and effects which are not the objects of sense. The consequence is obvious.

His morality is extravagant.

Kant's *political* opinions are said to be tolerably moderate, though he betrays, what we must think, an absurd confidence in the *unlimited perfectibility* of the human mind. On his morality our valued correspondent has bestowed a much larger share of his approbation than we can allow it of ours. Kant seems to contend, that the actions of men should be directed to no end whatever; for he expressly condemns, as an end of action, the pursuit either of our own happiness or of the happiness of others, whether temporal or eternal; but actions performed for no purpose are surely indications of the very essence of folly. Such actions are indeed impossible to beings endowed with reason, passions, and appetites; for if there be that beauty in abstract virtue, for which Kant and the Stoics contend, it cannot be but that the virtuous man must feel an internal pleasure when he performs a virtuous action, or reflects upon his past conduct. He who makes his temporal interest the sole rule of his conduct, has indeed no pretensions to the character of a virtuous man; but as the morality of the gospel has always appeared to us sufficiently pure and disinterested, we think a man may, without deviating into vice, have respect unto "the recompence of future reward."

Phosphorus.

PHOSPHORUS (See CHEMISTRY-*Index, Supplement.*) has lately been employed as a medicine by Alphonsus Leroi, professor at the Medical School of Paris. Its effects, in a variety of cases, are thus described in the *Bulletin de la Societe Philomatique,* 1798.

1. Phosphorus administered internally in consumptive diseases appears to give a certain degree of activity to life, and to revive the patients, without raising their pulse in the same proportion. The author relates several instances that occurred to him in the course of his practice;

practice; one of which is as follows: Being called to attend a woman, at the point of death, who was quite worn out by a consumptive disorder, with which she had been afflicted for three years, in compliance with the earnest desire of her husband, who requested him to give her some medicine, he composed one of a portion of sirup diluted with water, in which a few sticks of phosphorus had been kept. Next day the woman found herself much better. She was revived for a few days; and did not die till about a fortnight after.

2. He himself, as he acknowledges, was so imprudent as to take two or three grains of solid phosphorus combined only with treacle, and experienced the most dreadful symptoms. At first he felt a burning heat in the whole region of the stomach. That organ seemed to be filled with gas which escaped by the mouth. Being dreadfully tormented, he tried to vomit, but in vain; and found relief only by drinking cold water from time to time. His uneasy sensations were at length al- but next morning he seemed to be endowed with an astonishing muscular force, and to be urged with an almost irresistible impulse to try its energy. The effect of this medicine at length ceased, adds the author, *à la suite d'un priapisme violent.*

3. In many cases the author employed, and still employs, phosphorus internally, with great benefit, to restore and revive young persons exhausted by excesses. He divides the phosphorus into very small particles, by shaking it in a glass filled with boiling water. He continues to shake the bottle, plunging it into cold water, and thus obtains a kind of precipitate of phosphorus, exceedingly fine, which he bruises slowly with a little oil and sugar, or afterwards employs as liquid electuary, by diluting the whole in the yolk of an egg. By means of this medicine he has effected astonishing cures, and restored the strength of his patients in a very short time.

4. In malignant fevers the use of phosphorus internally, to check the progress of gangrene, has succeeded beyond expectation. The author relates several instances. Pelletier told him, that having left, through negligence, some phosphorus in a copper bason, that metal was oxydated, and remained suspended in the water. Having thoughtlessly thrown out the water in a small court in which ducks were kept, these animals drink of it, and all died. *Mais le male* (says the author) *couvrit toutes ses femelles jusque au dernier instant de sa vie.* An observation which accords with the effect experienced by the author.

6. The author relates a fact which proves the astonishing divisibility of phosphorus. Having administered to a patient some pills, in the composition of which there was not more than a quarter of a grain of phosphorus, and having had occasion afterwards to open the body, he found all the internal parts luminous; and even the hands of the person who had performed the operation, though washed and well dried, retained a phosphoric splendor for a long time after.

7. The phosphoric acid, employed as lemonade, has been serviceable to the author in the cure of a great number of diseases.

8. Leroi assures us that he oxydated iron with phosphorus, and obtained, by the common means, a white oxyd, almost irreducible, which he thinks may be employed with advantage in the arts, and particularly in painting with oil, and in enamel, instead of the white oxyd of lead. This white oxyd of iron occasioned violent retchings to the author, who ventured to place a very small particle of it on his tongue. He does not hesitate, therefore, to consider this oxyd as a terrible poison. He was not able to reduce it but by fixed alkali and the glass of phosphorus.

9. The author asserts that, by means of phosphorus, he decomposed and separated from their bases the sulphuric, muriatic, and nitric acids; that by help of the phosphoric acid he transmuted earths; and that with calcareous earth he can make, at pleasure, considerable quantities of magnesia. He declares, that to his labours on phosphorus he is indebted for processes by which he effects the dissipation (*opère la frite*) of rubies, the fusion of emeralds, and the vitrification of mercury.

We agree with the editor of the respectable Miscellany *, from which we have immediately taken this article, that British practitioners will do well to use their wonted caution in the application of so powerful a remedy. Indeed we consider it as so very *hazardous* a remedy, that we had resolved to make no mention of it, till we found it transcribed into various journals, both foreign and domestic, and thence began to suspect that we might be accused of culpable negligence, were we to pass unnoticed what had attracted the attention of so many of our fellow-labourers in the field of science.

Phosphorus, in astronomy, is the morning star, or the [illegible] The Latins [illegible] and the G[illegible]

PHOTOMETER, [illegible] the intensity [illegible] the medium [illegible] Instruments for this purpose have been invented by Count Rumford, M. de Saussure, the eminent mathematician and philosopher Mr John Leslie, and others. We shall content ourselves with describing in this place the photometer of Count Rumford, and the instrument to which Saussure gives the name of *diaphanometer*. Mr Leslie's is indeed the simplest instrument of the kind of which we have anywhere met with a description; but it measures only the momentary intensities of light; and he who wishes to be informed of its construction, will find that information in the third volume of Nicholson's Philosophical Journal.

Count Rumford, when making the experiments which we have noticed in the article Lamp (*Suppl.*), was led, step by step, to the construction of a very accurate *photometer*, in which the shadows, instead of being thrown upon a paper spread out upon the wainscot, or side of the room (See page 64 of this volume), are projected upon the inside of the back part of a wooden box $7\frac{1}{2}$ inches wide, $10\frac{1}{2}$ inches long, and $3\frac{1}{2}$ inches deep, in the clear. The light is admitted into it through two horizontal tubes in the front, placed so as to form an angle of 60°; their axes meeting at the centre of the field of the instrument. In the middle of the front of the box, between these two tubes, is an opening thro' which is viewed the field of the photometer (See fig. 1.). Plate XLI. This field is formed of a piece of white paper, which is not fastened immediately upon the inside of the back of the box, but is pasted upon a small pane of very fine ground glass; and this glass, thus covered,

* Philosophical Magazine, vol

Photometer.

is let down into a groove, made to receive it, in the back of the box. The whole inside of the box, except the field of the instrument, is painted of a deep black dead colour. To the under part of the box is fitted a ball and socket, by which it is attached to a stand which supports it; and the top or lid of it is fitted with hinges, in order that the box may be laid quite open, as often as it is necessary to alter any part of the machinery it contains.

The Count had found it very inconvenient to compare two shadows projected by the same cylinder, as these were either necessarily too far from each other to be compared with certainty, or, when they were nearer, were in part hid from the eye by the cylinder. To remedy this inconvenience, he now makes use of two cylinders, which are placed perpendicularly in the bottom of the box just described, in a line parallel to the back part of it, distant from this back $2\frac{3}{10}$ inches, and from each other 3 inches, measuring from the centres of the cylinders; when the two lights made use of in the experiment are properly placed, these two cylinders project four shadows upon the white paper upon the inside of the back part of the box, or the *field* of the instrument; two of which shadows are in contact, precisely in the middle of that field, and it is these two alone that are to be attended to. To prevent the attention being [illegible] unnecessary objects, the [illegible] [illegible] be [illegible] of the [illegible] large [illegible] pro- [illegible] to [illegible] of [illegible] be [illegible] be [illegible] inches long [illegible] deep, viz. $3\frac{1}{2}$ inches; since the field [illegible] can be reduced to its proper size by a [illegible] pasteboard, interposed before the anterior [illegible] glass, and resting immediately upon it. [illegible] pasteboard, in the form of an oblong square, [illegible] wide, and two inches high, determines the dimensions, and forms the boundaries of the field. This screen should be large enough to cover the whole inside of the back of the box, and it may be fixed in its place by means of grooves in the sides of the box, into which it may be made to enter. The position of the opening above-mentioned is determined by the height of the cylinders; the top of it being $\frac{1}{10}$ of an inch higher than the tops of the cylinders; and as the height of it is only two inches, while the height of the cylinders is $2\frac{3}{10}$ inches, it is evident that the shadows of the lower parts of the cylinders do not enter the field. No inconvenience arises from that circumstance; on the contrary, several advantages are derived from that arrangement.

That the lights may be placed with facility and precision, a fine black line is drawn through the middle of the field, from the top to the bottom of it, and another (horizontal) line at right angles to it, at the height of the top of the cylinders. When the tops of the shadows touch this last mentioned line, the lights are at a proper height; and farther, when the two shadows are in contact with each other in the middle of the field, the lights are then in their proper directions.

We have said that the cylinders, by which the shadows are projected, are placed perpendicularly in the bottom of the box; but as the diameters of the shadows of these cylinders vary in some degree, in proportion as the lights are broader or narrower, and as they are brought nearer to or removed farther from the photometer, in order to be able in all cases to bring these shadows to be of the same diameter, which is very advantageous, in order to judge with greater facility and certainty when they are of the same density, the Count renders the cylinders moveable about their axes, and adds to each a vertical wing $\frac{45}{100}$ of an inch wide, $\frac{1}{20}$ of an inch thick, and of equal height with the cylinder itself, and firmly fixed to it from the top to the bottom. This wing commonly lies in the middle of the shadow of the cylinder, and as long as it remains in that situation it has no effect whatever; but when it is necessary that the diameter of one of the shadows be increased, the corresponding cylinder is moved about its axis, till the wing just described, emerging out of the shadow, and intercepting a portion of light, brings the shadow projected upon the field of the instrument to be of the width or diameter required. In this operation it is always necessary to turn the cylinder outwards, or in such a manner that the augmentation of the width of the shadow may take place on that side of it which is opposite to the shadow corresponding to the other light. The necessity for that precaution will appear evident to any one who has a just idea of the instrument in question, and of the manner of making use of it. They are turned likewise without opening the box, by taking hold of the ends of their axes, which project below its bottom.

As it is absolutely necessary that the cylinders should constantly remain precisely perpendicular to the bottom of the box, or parallel to each other, it will be best to construct them of brass; and, instead of fixing them immediately to the bottom of the box (which, being of wood, may warp), to fix them to a strong thick piece of well-hammered plate brass; which plate of brass may be afterwards fastened to the bottom of the box by means of one strong screw. In this manner two of the Count's best instruments are constructed; and, in order to secure the cylinders still more firmly in their vertical positions, they are furnished with broad flat rings, or projections, where they rest upon the brass plate; which rings are $\frac{1}{10}$ of an inch thick, and equal in diameter to the projection of the wing of the cylinder, to the bottom of which they afford a firm support. These cylinders are likewise forcibly pushed, or rather pulled, against the brass plate upon which they rest, by means of compressed spiral springs placed between the under side of that plate and the lower ends of the cylinders. Of whatever material the cylinders be constructed, and whatever be their forms or dimensions, it is absolutely necessary that they, as well as every other part of the photometer, except the field, should be well painted of a deep black dead colour.

In order to move the lights to and from the photometer with greater ease and precision, the observer should provide two long and narrow, but very strong and steady, tables; in the middle of each of which there

there is a straight groove, in which a sliding carriage, upon which the light is placed, is drawn along by means of a cord which is fastened to it before and behind, and which, passing over pulleys at each end of the table, goes round a cylinder; which cylinder is furnished with a winch, and is so placed, near the end of the table adjoining the photometer, that the observer can turn it about, without taking his eye from the field of the instrument.

Many advantages are derived from this arrangement: First, the observer can move the lights as he finds necessary, without the help of an assistant, and even without removing his eye from the shadows; secondly, each light is always precisely in the line of direction in which it ought to be, in order that the shadows may be in contact in the middle of the vertical plane of the photometer; and, thirdly, the sliding motion of the lights being perfectly soft and gentle, that motion produces little or no effect upon the lights themselves, either to increase or diminish their brilliancy.

These tables must be placed at an angle of 60 degrees from each other, and in such a situation, with respect to the photometer, that lines drawn through their middles, in the direction of their lengths, meet in a point exactly under the middle of the vertical plane or field of the photometer, and from that point the distances of the lights are measured; the sides of the tables being divided into English inches, and a vernier, shewing tenths of inches, being fixed to each of the sliding carriages upon which the lights are placed, and which are so contrived that they may be raised or lowered at pleasure; so that the lights may be always in a horizontal line with the tops of the cylinders of the photometer.

In order that the two long and narrow tables or platforms, just described, may remain immoveable in their proper positions, they are both firmly fixed to the stand which supports the photometer; and, in order that the motion of the carriages which carry the lights may be as soft and gentle as possible, they are made to slide upon parallel brass wires, 9 inches asunder, about $\frac{1}{10}$ of an inch in diameter, and well polished, which are stretched out upon the tables from one end to the other.

The structure of the apparatus will be clearly understood by a bare inspection of Plate XLI. where fig. 1. is a plan of the inside of the box, and the adjoining parts of the photometer. Fig. 2. Plan of the two tables belonging to the photometer. Fig. 3. The box of the photometer on its stand. Fig. 4. Elevation of the photometer, with one of the tables and carriages.

Having sufficiently explained all the essential parts of this photometer, it remains for us to give some account of the precautions necessary to be observed in using it. And, first, with respect to the distance at which lights, whose intensities are to be compared, should be placed from the field of the instrument, the ingenious and accurate inventor found, that when the weakest of the lights in question is about as strong as a common wax candle, that light may most advantageously be placed from 30 to 36 inches from the centre of the field; and when it is weaker or stronger, proportionally nearer or farther off. When the lights are too near, the shadows will not be well defined; and when they are too far off, they will be too weak.

It will greatly facilitate the calculations necessary in drawing conclusions from experiments of this kind, if some steady light, of a proper degree of strength for that purpose, be assumed as a standard by which all others may be compared. Our author found a good Argand's lamp much preferable for this purpose to any other lamp or candle whatever. As it appears, he says, from a number of experiments, that the quantity of light emitted by a lamp, which burns in the same manner with a clear flame, and *without smoke*, is in all cases as the quantity of oil consumed, there is much reason to suppose, that, if the Argand's lamp be so adjusted as always to consume a given quantity of oil in a given time, it may then be depended on as a just standard of light.

In order to abridge the calculations necessary in these inquiries, it will always be advantageous to place the standard-lamp at the distance of 100 inches from the photometer, and to assume the intensity of its light at its source equal to unity; in this case (calling this standard light A, the intensity of the light at its source $= x = 1$, and the distance of the lamp from the field of the photometer $= m = 100$), the intensity of the illumination at the field of the photometer $(= \frac{x}{m^2})$ (See Lamp, p. 67. of this volume) will be expressed by the fraction $\frac{1}{100^2} = \frac{1}{10000}$; and the relative intensity of any other light, which is compared with it, may be found by the following proportion: Calling this light B, putting $y =$ its intensity at its source, and $n =$ its distance from the field of the photometer, expressed in English inches, as it is $\frac{y}{n^2} = \frac{x}{m^2}$, as was shewn in the article Lamp, referred to; or, instead of $\frac{x}{m^2}$, writing its value $= \frac{1}{10000}$, it will be $\frac{y}{n^2} = \frac{1}{10000}$; and consequently y is to 1 as n^2 is to 10000; or the intensity of the light B at its source, is to the intensity of the standard light A at its source, as the square of the distance of the light B from the middle of the field of the instrument, expressed in inches, is to 10000; and hence it is $y = \frac{n^2}{10000}$.

Or, if the light of the sun, or that of the moon, be compared with the light of a given lamp or candle C, the result of such comparison may best be expressed in words, by saying, that the light of the celestial luminary in question, *at the surface of the earth*, or, which is the same thing, at the field of the photometer, is equal to the light of the given lamp or candle, *at the distance found by the experiment*; or, putting $a =$ the intensity of the light of this lamp C at its source, and $p =$ its distance, in inches, from the field, when the shadows corresponding to this light, and that corresponding to the celestial luminary in question, are found to be of equal densities, and putting $z =$ the intensity of the rays of the luminary at the surface of the earth, the result of the experiment may be expressed thus, $z = \frac{a}{p^2}$; or the real value of a being determined by a particular experiment, made expresly for that purpose with the standard lamp, that value may be written instead of it. When the standard-lamp itself is made use of, instead of the lamp C, then the value of A will be 1.

The Count's first attempts with his photometer were to determine how far it might be possible to ascertain,

by

by direct experiments, the certainty of the assumed law of the diminution of the intensity of the light emitted by luminous bodies; namely, that the intensity of the light is everywhere as the squares of the distances from the luminous body inversely. As it is obvious that this law can hold good only when the light is propagated through perfectly transparent spaces, so that its intensity is weakened merely by the divergency of its rays, he instituted a set of experiments to ascertain the transparency of the air and other mediums

With this view, two equal wax. candles, well trimmed, and which were found, by a previous experiment, to burn with exactly the same degree of brightness, were placed *together*, on one side, before the photometer, and their united light was counterbalanced by the light of an Argand's lamp, well trimmed, and burning very equally, placed on the other side over against them. The lamp was placed at the distance of 100 inches from the field of the photometer, and it was found that the two burning candles (which were placed as near together as possible, without their flames affecting each other by the currents of air they produced) were just able to counterbalance the light of the lamp at the field of the photometer, when they were placed at the distance of 60,8 inches from that field. One of the candles being now taken away and extinguished, the other was brought nearer to the field of the instrument, till its light was found to be just able, singly, to counterbalance the light of the lamp; and this was found to happen when it had arrived at the distance of [illegible] In this experiment, as the candles burnt [illegible] brightness, it is evident that the intensities [illegible]ted and single lights were as 2 to 1, and in [illegible]tion ought, according to the assumed theo[illegible]ares of the distances, 60,8 and 43,4, to be; and, in fact, $\overline{60,8}^2 = 3696,64$ is to $\overline{43,4}^2 = 1883,56$ as 2 is to 1 very nearly.

Again, in another experiment, the distances were,

With two candles = 54 inches. Square = 2916

With one candle = 38,6 - - = 1489,96

Upon another trial,

With two candles = 54,6 inches. Square = 2981,16

With one candle = 39,7 - - = 1576,09

And, in the fourth experiment,

With two candles = 58,4 inches. Square = 3410,56

With one candle = 42,2 - - = 1780,84

And, taking the mean of the results of these four experiments,

	Squares of the Distances With two Candles.		With one Candle.
In the Experiment N° 1.	3696,64	—	1883,56
N° 2.	2916	—	1489,96
N° 3.	2981,16	—	1576,09
N° 4.	3410,56	—	1780,84
	4) 13004,36		4) 6730,45
Means	3251,09	and	1682,61

which again are very nearly as 2 to 1.

With regard to these experiments, it may be observed, that were the resistance of the air to light, or the diminution of the light from the imperfect transparency of air, sensible within the limits of the inconsiderable distances at which the candles were placed from the photometer, in that case the distance of the two equal lights united ought to be, to the distance of one of them single, in a ratio less than that of the square root of 2 to the square root of 1. For if the intensity of a light emitted by a luminous body, *in a space void of all resistance*, be diminished in the proportion of the squares of the distances, it must of necessity be diminished in a still higher ratio when the light passes thro' a resisting medium, or one which is not perfectly transparent; and from the difference of those ratios, namely, that of the squares of the distances, and that other higher ratio found by the experiment, the resistance of the medium might be ascertained. This he took much pains to do with respect to air, but did not succeed; the transparency of air being so great, that the diminution which light suffers in passing through a few inches, or even through several feet of it, is not sensible.

Having found, upon repeated trials, that the light of a lamp, properly trimmed, is incomparably more equal than that of a candle, whose wick, continually growing longer, renders its light extremely fluctuating, he substituted lamps to candles in these experiments, and made such other variations in the manner of conducting them as he thought bid fair to lead to a discovery of the resistance of the air to light, were it possible to render that resistance sensible within the confined limits of his machinery. But the results of them, so far from affording means for ascertaining the resistance of the air to light, do not even indicate any [illegible] the contrary, it might almost be inf[illegible] them, that the intensity of the ligh[illegible] minous body in air is diminished in a [illegible] of the squares of the distances; but as such a conclusion would involve an evident absurdity, namely, that light moving in air, its absolute quantity, instead of being diminished, actually goes on to *increase*, that conclusion can by no means be admitted.

Why not? Theories must give place to facts; and if this fact can be fairly ascertained, instead of rejecting the conclusion, we ought certainly to rectify our notions of light, the nature of which we believe no man fully comprehends. Who can take it upon him to say, that the substance of light is not latent in the atmosphere, as heat or caloric is now acknowledged to be latent, and that the agency of the former is not called forth by the passage of a ray through a portion of air, as the agency of the latter is known to be excited by the combination of oxygen with any combustible substance? See Chemistry, n° 293, *Suppl.*

The ingenious author's experiments all conspired to shew that the resistance of the air to light is too inconsiderable to be perceptible, and that the assumed law of the diminution of the intensity of light may be depended upon with safety. He admits, however, that means may be found for rendering the air's resistance to light apparent; and he seems to have thought of the very means which occurred for this purpose to M. de Saussure.

That eminent philosopher, wishing to ascertain the transparency of the atmosphere, by measuring the distances at which determined objects cease to be visible, perceived at once that his end would be attained if he should find objects of which the disappearance might be accurately determined. Accordingly, after many trials, he found that the moment of disappearance can be observed with much greater accuracy when a black

Photometer.

object is placed on a white ground, than when a white object is placed on a black ground; that the accuracy was still greater when the observation was made in the sun than in the shade; and that even a still greater degree of accuracy was obtained, when the white space surrounding a black circle, was itself surrounded by a circle or ground of a dark colour. This last circumstance was particularly remarkable, and an observation quite new.

If a circle totally black, of about two lines in diameter, be fastened on the middle of a large sheet of paper or pasteboard, and if this paper or pasteboard be placed in such a manner as to be exposed fully to the light of the sun, if you then approach it at the distance of three or four feet, and afterwards gradually recede from it, keeping your eye constantly directed towards the black circle, it will appear always to decrease in size the farther you retire from it, and at the distance of 33 or 34 feet will have the appearance of a point. If you continue still to recede, you will see it again enlarge itself; and it will seem to form a kind of cloud, the darkness of which decreases more and more according as the circumference becomes enlarged. The cloud will appear still to increase in size the farther you remove from it; but at length it will totally disappear. The moment of the disappearance, however, cannot be accurately ascertained; and the more experiments were repeated the more were the results different.

M. de Saussure, having reflected for a long time on the means of remedying this inconveniency, saw clearly, that, as long as this cloud took place, no accuracy could be obtained; and he discovered that it appeared in consequence of the contrast formed by the white parts which were at the greatest distance from the black circle. He thence concluded, that if the ground was left white near this circle, and the parts of the pasteboard at the greatest distance from it were covered with a dark colour, the cloud would no longer be visible, or at least almost totally disappear.

This conjecture was confirmed by experiment. M. de Saussure left a white space around the black circle equal in breadth to its diameter, by placing a circle of black paper a line in diameter on the middle of a white circle three lines in diameter, so that the black circle was only surrounded by a white ring a line in breadth. The whole was pasted upon a green ground. A green colour was chosen, because it was dark enough to make the cloud disappear, and the easiest to be procured.

The black circle, surrounded in this manner with white on a green ground, disappeared at a much less distance than when it was on a white ground of a large size.

If a perfectly black circle, a line in diameter, be pasted on the middle of a white ground exposed to the open light, it may be observed at the distance of from 44 to 45 feet; but if this circle be surrounded by a white ring a line in breadth, while the rest of the ground is green, all sight of it is lost at the distance of only 15½ feet.

According to these principles M. de Saussure delineated several black circles, the diameters of which increased in a geometrical progression, the exponent of which was $\frac{3}{2}$. His smallest circle was $\frac{1}{5}$ or 0·2 of a line in diameter; the second 0·3; the third, 0·45; and so on to the sixteenth, which was 87·527, or about 7 inches 3½ lines. Each of these circles was surrounded by a white ring, the breadth of which was equal to the diameter of the circle, and the whole was pasted on a green ground.

M. de Saussure, for his experiments, selected a straight road or plain of about 1200 or 1500 feet in circumference, which towards the north was bounded by trees or an ascent. Those who repeat them, however, must pay attention to the following remarks: When a person retires backwards, keeping his eye constantly fixed on the pasteboard, the eye becomes fatigued, and soon ceases to perceive the circle; as soon therefore as it ceases to be distinguishable, you must suffer your eyes to rest; not, however, by shutting them, for they would when again opened be dazzled by the light, but by turning them gradually to some less illuminated object in the horizon. When you have done this for about half a minute, and again directed your eyes to the pasteboard, the circle will be again visible, and you must continue to recede till it disappear once more. You must then let your eyes rest a second time in order to look at the circle again, and continue in this manner till the circle becomes actually invisible.

If you wish to find an accurate expression for the want of transparency, you must employ a number of circles, the diameters of which increase according to a certain progression; and a comparison of the distances at which they disappear will give the law according to which the transparency of the atmosphere decreases at different distances. If you wish to compare the transparency of the atmosphere on two days, or in two different places, two circles will be sufficient for the experiment.

According to these principles, M. de Saussure caused to be prepared a piece of white linen cloth eight feet square. In the middle of this square he sewed a perfect circle, two feet in diameter, of beautiful black wool; around this circle he left a white ring two feet in breadth, and the rest of the square was covered with pale green. In the like manner, and of the same materials, he prepared another square; which was, however, equal to only $\frac{1}{12}$ of the size of the former, so that each side of it was 8 inches; the black circle in the middle was two inches in diameter, and the white space around the circle was 2 inches also.

If two squares of this kind be suspended vertically and parallel to each other, so that they may be both illuminated in an equal degree by the sun; and if the atmosphere, at the moment when the experiment is made, be perfectly transparent, the circle of the large square, which is twelve times the size of the other, must be seen at twelve times the distance. In M. de Saussure's experiments the small circle disappeared at the distance of 314 feet, and the large one at the distance of 3588 feet, whereas it should have disappeared at the distance of 3768. The atmosphere, therefore, was not perfectly transparent. This arose from the thin vapours which at that time were floating in it. M. de Saussure, as we have observed, calls his instrument a *diaphanometer*; but as it answers one of the purposes of a photometer, we trust our readers will not consider this account of it as a digression.

To return to Count Rumford. From a number of experiments made with his *photometer*, he found that, by passing through a pane of fine, clear, well polished glass, such as is commonly made use of in the construction of looking-glasses, light loses ,1973 of its whole quantity,

quantity, *i. e.* of the quantity which impinged on the glafs; that when light is made to pafs through two panes of fuch glafs ftanding parallel, but not touching each other, the lofs is ,3184 of the whole; and that in paffing through a very thin, clear, colourlefs pane of window-glafs, the lofs is only ,1263. Hence he infers, that this apparatus might be very ufefully employed by the optician, to determine the degree of tranfparency of glafs, and direct his choice in the provifion of that important article of his trade. The lofs of light when reflected from the very beft plain glafs mirror, the author afcertained, by five experiments, to be $\frac{1}{3}$d of the whole which fell upon the mirror.

PIANO FORTE, otherwife called FORTE PIANO, a well-known mufical inftrument, of which we need make no apology for confidering the peculiarities with fome attention. If we look on mufic from no higher point of view than as the *laborum dulce lenimen*, the innocent, the foothing, the chearing fweetener of toil, we muft acknowledge that it is far from being the meaneft of thofe enjoyments with which the Bountiful Father of Men has embellifhed this fcene of our exiftence. But there is a *fcience* in mufic, independent of that artificial half mathematical doctrine which we have contrived to unite with it, and which really enables us to improve pure mufical pleafure. Hence in the Englifh univerfities degrees are conferred in mufic.

The voice [illegible] inftrument, and all others [illegible] The voice of man obeys the impulfe of [illegible] promptitude, and [illegible] very coarfe ear is [illegible] to what is called [illegible] melodies extending to 12 notes [illegible]. The motion of the glottis [illegible] does not amount to [illegible]th of an inch [illegible] therefore be divided, by the moft [illegible] more than a thoufand parts; and this [illegible] in an inftant, and repeated with [illegible] miftaking one of thefe divifions; and this is [illegible]where, and without any feeming effort or thought. The mechanifm of the human organ for effecting this with eafe and precifion is very remarkable, and feems to prove that the Author of our Being meant to give us this pleafure.

When, in the cultivation of this fruit of our own foil, the moderns difcovered the beauties of harmony or confonance, and inftruments of fixed founds were employed, by means of which thefe beauties could be exhibited in their utmoft richnefs and variety; and particularly when the organ, that "magic world of found," was invented, the immenfe advantages of the ingenious fpeculations of the ancient Greeks about the divifion of the monochord were now perceived, and mufic became a deep intellectual ftudy. It fell into the hands of men of letters, and, for a long while, counterpoint occupied all their attention. Inftruments of fixed founds were now made, not only with pipes, but with ftrings, bells, rings, and every thing that could make a noife in tune.

But all thefe inftruments were far inferior to the voice, the fpontaneous gift of Nature, in promptitude, and in the power of obeying every call of fentiment, every degree, as well as every kind of emotion, with which the heart was agitated. The pleafures of harmony, though great, were monotonous, and could not exprefs the momentary variations of fentiment, which are as fleeting as the light and fhade of a profpect while the dappled clouds fail acrofs the fky. The violin, and a fmall number of the fimple wind inftruments, were found to be the only ones which could fully exprefs thofe momentary gradations of fentiment that give mufic its pathos, and enable it to thrill the very foul.

Piano Forte.

Attempts were made to remove this defect of the harmonic inftruments, and the SWELL was added to the organ. The effect was great, and encouraged the artifts to attempt fimilar improvements on other inftruments of the fame kind. This was firft done in the fame way as in the organ. The harpfichord was fhut up, like the fwell organ, and was opened by means of pedals when the performer wifhed to enforce the found. But the effect was far inferior to that of the fwell organ; for this was (at leaft in all great organs) a real addition of another properly felected found. But the effect of the pedal on the harpfichord could not be miftaken; it was juft like opening the door of a room where mufic was performing. Other methods were tried with better effect. Unifons were added to each note, which were brought on either by means of pedals or by another fet of keys.

This method fucceeded perfectly well, and the power of the harpfichord was greatly improved. But ftill it was imperfect, becaufe it was only the more confiderable changes of force which could be exhibited, and this only in one or two degrees. Other artifts, therefore, attempted to conftruct the inftrument, fo that the jacks (the moveable upright pieces which carry the quills) can be made to approach nearer to the wires, fo that the quills fhall give them a ftronger twang. The mechanifm was fuch, that a very confiderable motion of the pedal produced but a moft minute motion of the quill; fo that the performer was not reftricted to the utmoft precifion in the degree of preffure. Some of thofe inftruments, when frefh from the hand of the artift, gave full fatisfaction. But, though made in the moft accurate manner, at an enormous expence, they very foon become unfit for the purpofe. The hundredth part of an inch, more or lefs, in the place of the quill, will make a great odds in the force of the found. Nor does the fame change of diftance produce an equal alteration of found on different quills. Other inftrument makers have therefore tried baked or prepared leather (buffalo hide) in place of quills; and it is found much more uniform in the tone which it produces, and alfo remains longer in the fame ftate; but the tone is not fo powerful, nor in general fo much relifhed.

But all thefe contrivances, both in the organ and harpfichord, were ftill very deficient. Whatever change they could produce in the ftrength of the found, was produced through the whole inftrument, or at leaft through two or three octaves. But the captivating expreffion of mufic frequently refults from the momentary fwelling or foftening of a fingle phrafe, or a fingle note, in one of the parts. Hence arife the unrivalled powers of the harp, and the acknowledged fuperiority of the theorbo, the lute, and even the guitar, over all keyed inftruments, notwithftanding their great limitations in harmony and in practicable melodies. Thefe inftruments fpeak, while the harpfichord only plays.

Many attempts have been made to enable the performer to produce, by the intervention of the key, all the gradations of ftrength, and even the varieties of

 found,

sound, which the finger can bring forth by the different manner of pinching, brushing, or, as it were, caressing the string; but we have no distinct account of any attempt that has succeeded. Such a thing would quickly spread over Europe. The compiler of the article LUTHIER, in the *Encyclopedie Methodique*, says a great deal about a harpsichord fitted with prepared buffalo leather instead of crow quills; and asserts expressly, that, by the mere pressure on the key, without the assistance of pedals or stops of any kind, the leather is made to act with greater or less force on the string. But he gives no account by which we can comprehend how this is brought about; and indeed he writes in terms which shew plainly that he has not seen the instrument, and is merely puffing something that he does not understand.

The attempt has been made with more success on keyed instruments, when the strings are not pinched, but are rubbed by a wheel or band, in the manner of the vielle (hurdygurdy), or struck with a plectrum, like the dulcimer. The CELESTINA (described by Mersennus by the name of ARCHIVIOLA) is of this kind. A fine band of horse hair or silk, filled with rosin, is extended under the strings, and drawn smoothly along by a wheel. By a particular mechanism of the keys, this band is made to press or rub on any string transversely, as the strings of a violin are touched by the bow. The pressure on the key regulates the strength of the tone. This instrument is not without considerable beauties, and will execute soft *cantabile* music in easy modulation, with great expression and justness. But the artists have not yet been able to give it either clearness or brilliancy of tone, nor sufficient force for concert music, nor that promptitude of touch that is indispensably necessary for figurative music or quick movements.

The same improvements have been made on the pulsatile instruments; and indeed they are here the most obvious and easy. When the key is employed merely as the means of causing a plectrum to give a blow to the string, the performer will hardly fail to give that degree of force which he feels proper for his intended expression. Accordingly, many instruments of this kind have been made in Germany, where the artists have long been eminent for mechanical knacks. But all their instruments of the dulcimer kind are feeble and spiritless, and none of them have been brought into general use, if we except the CLAVICHORD. This is indeed an instrument of feeble, and not the most pleasing sound; but is well fitted for giving every momentary gradation of strength by the pressure of the finger. Is is therefore a good instrument for forming the musical taste by chamber practice, and was much used by compositors in their studies. It is also an ingenious, though seemingly an obvious and simple contrivance, and is capable of much more force, and even brilliancy of sound, than has generally been given to it.

The construction is shortly this. The inner end of the key is furnished with an upright piece, which terminates in an edge of brass, somewhat like the end of a narrow blunt chisel, whose line of direction is athwart the strings. When the key is pressed down, this edge strikes the string, and forces it out of the straight line in which it is stretched between its pins. Thus the string is shaken or jogged into vibration, in the same manner as we observe a tight rope set a vibrating by a sudden jerk given to any part of it. The string, thus agitated, gives a sound, which will continue for some little time if the key be held down. As the tone depends on the length of the vibrating string, as well as on its tension, it is of importance that the stroke be made on the precise point of the string which terminates the proper length. The string does not give the note corresponding to its whole length, but that which is produced by the part between the edge and the pin. And because the parts of the string on each side of the edge are equally thrown into vibration, the shorter portion of it must be wrapped up in a list of cloth, to prevent it from disturbing the ear by its sonorous vibrations. This, however, greatly diminishes the sweetness of the sound given by the other part.

The clavichord gives a fretful waspish kind of sound, not at all suited to tender expression. If the bridge (for the end of the key is really a bridge during the sound) were placed at an exact third of the length of the string, and if both parts were free, and if the stroke be of a proper strength, the string would sound its twelfth with great sweetness, and with much more force and brilliancy than it does by the present construction, and the clavichord would be a charming instrument for a lesson and for private study. We say this from experience of the power of one constructed under the direction of the great mathematician Euler, who was also an excellent judge of music and musical composition. The tones of the upper part of that instrument had a sort of pipe or vocal sound, and were superior in clearness and sweetness to any stringed instrument we ever heard. But as this construction required every string to be one half longer than a harpsichord wire of the same pitch, and as this would have made the instrument of a most inconvenient size, the basses were made shorter, by placing the bridge at one-sixth of the length, and loading the shorter portion of the string with wire twisted round it. But although this was executed by a most dexterous artist, the tones were far inferior to those of the trebles, and the instrument was like the junction of a very fine one and a very bad one, and made but hobbling music. This was probably owing to the impossibility of connecting the metal wire and its covering with sufficient closeness and solidity. An upright clavichord, where the length would be no inconvenience, would be indeed a capital instrument for musical study. It is worthy of remark, that Mr Euler tried other divisions of the string by the bridge. When it is struck precisely in the middle, it should sound its octave; when it is struck at one-fourth, it should give the double octave, &c. But the maker found that these divisions gave very indifferent, and even uncertain tones; sometimes not sounding at all, and sometimes sounding beautifully. Our readers will find this well explained in a future article of this *Supplement*, (TRUMPET, *Marine*). They may please to reflect on the very different tone of the violin as it is bowed on different parts of the string, and on the very different tones of the fore and back unisons, and particularly of the Cornet stop of the harpsichord. The harpsichords of Rucker are noted for the grand fulness of their tone; those of Hasse of Dresden for their mellow sweetness, and those of Kirkmann of London for their unequalled brilliancy. These makers differed greatly in the placing of their quills.

But the English PIANO FORTE, by its superior force of tone, its adequate sweetness and the great variety of voice of which our artists have made it susceptible, has with-

withdrawn all farther attention from the clavichord, ſo that it is no longer probable that the learned contribution of the great Euler to public amuſement will be followed up. The Piano forte correſponds to its name with great preciſion: For, without any other attention or effort than what ſentiment ſpontaneouſly dictates, and what we practiſe (without knowing it) on the harpſichord, where it is ineffectual, we make the Piano-forte give every gradation of ſtrength to the ſound of the ſtring, and give it every expreſſion that an inſtrument, purely pulſatile, is capable of. It is alſo ſuſceptible of a very conſiderable variety of tone by the clothing of the mallets, which may be acute or obtuſe, hard or ſoft. And we ſee, by the effect of what are called the grand Piano fortes, that they are fully equal to the harpſichord in fulneſs or body of tone. Nothing ſeems to be wanting to it but that ſliding, or (as the French call it) *careſſing* touch of the ſtring, by which a delicate finger, guided by fine taſte, cauſes the harp or lute to melt the heart, and excite its fineſt emotions. We truſt that the ingenuity of our Britiſh artiſts will accompliſh even this, and make this national inſtrument rival even the violin of Italy.

We call it a *national inſtrument*, not doubting but that this is a recommendation to a Britiſh heart, and becauſe we are very well aſſured that it is an Engliſh contrivance; the invention of a moſt excellent man and celebrated poet, Mr William Maſon. His Caractacus and Elfrida may convince any perſon who is a judge of muſic, that he had a mind exquiſitely ſenſible of all its charms; and we cannot be ſurpriſed that it was one of his chief delights. No man enjoyed the pleaſures of muſic with more rapture; and he uſed to ſay, that his ſpeedieſt recruit from the fatigue of a long walk was to ſit down for a few minutes to the harpſichord. He had ſeen ſeveral of the German attempts to make keyed dulcimers, which were, in ſome meaſure, ſuſceptible of the *forte* and *piano*; But they were all on one principle, and required a particular touch of the finger, of difficult acquiſition, and which ſpoiled the harpſichord practice. We have alſo ſeen of thoſe inſtruments, ſome of very old date, and others of modern improvement. Some had very agreeable tones; but all were deficient in delicacy and juſtneſs. The performer was by no means certain of producing the very ſtrength of ſound that he intended. And, as Mr Maſon obſerved, they all required an artificial peculiarity of fingering; without which, either the intended ſtrength of tone was not brought out, or the tone was deſtroyed by repeated rattling of the mallet on the wire.

Mr Maſon removed all thoſe imperfections by detaching the mallet entirely from the key, and giving them a connection quite momentary. The ſketch in Plate XL. will give the reader a clear view of Mr Maſon's general principle, by which the Engliſh piano forte is diſtinguiſhed from all others. The parts are repreſented in their ſtate of inaction. The key ABK turns, as uſual, on the round edge of the bar B, and a pin *b*, driven into the bar, keeps it in its place. The dot F repreſents a ſection of the ſtring. ED is the mallet, having a hinge of vellum, by which it is attached to the upper ſurface of the bar E. At the other end is the head D, of wood, covered with ſome folds of prepared leather. The mallet lies in the poſition repreſented in the figure, its lower end reſting on a cuſhion-bar K, which lies horizontally under the whole row of mallets. The key AR has a pin C, tipt with a bit of the ſofteſt cork or buckſkin. This reaches to within $\frac{1}{10}$th of an inch of the ſhank of the mallet, but muſt not touch it. The diſtance E*e* is about $\frac{1}{3}$d or $\frac{1}{4}$th of the length of the ſhank. When the end A of the key is preſſed down on the ſtuffing (two or three thickneſſes of the moſt elaſtic woollen liſt) it raiſes the mallet, by means of the pin C, to the horizontal poſition E*d*, within $\frac{1}{8}$th or $\frac{1}{10}$th of an inch of the wire F; but it cannot be ſo much preſſed down as to make the mallet touch the wire. At the ſame time that the key raiſes the mallet by means of the pin C, it alſo lifts off the damper G (a bit of ſpunge) from the wire. This damper is fixed on the end of a little wooden pin G*g*, connected with the lever *g* H, which has a vellum hinge at H. This motion of the damper is cauſed by the pin I, which is fixed into the key near to R. Theſe pieces are ſo adjuſted, that the firſt touch of the key lifts the damper, and, immediately after, the pin C acts on the ſhank of the mallet. As it acts ſo near to its centre of motion, it cauſes the head D to move briſkly through a conſiderable arch D*d*. Being made extremely moveable, and very light, it is thus *toſſed* beyond the horizontal poſition E*d*, and it ſtrikes the wire F, which is now at liberty to vibrate up and down, by the previous removal of the damper G. Having made its ſtroke, the mallet falls down again, and reſts on the ſoft ſubſtance on the pin C. It is of eſſential importance that this mallet be extremely light. Were it heavy, it would have ſo much force, after rebounding from the wire, that it would rebound again from the pin C, and again ſtrike the wire. For it will be recollected, that the key is, at this time, down, and the pin C raiſed as high as poſſible, ſo that there is very little room for this rebound. Leſſening the momentum of the mallet by making it very light, making the cuſhion on the top of the pin C very ſoft, and great preciſion in the ſhape and figure of all the parts, are the only ſecurities againſt the diſagreeable rattling which theſe rebounds would occaſion. In reſpect to the ſolidity and preciſion of workmanſhip, the Britiſh inſtruments are unrivalled, and vaſt numbers of them are ſent to all parts of the continent.

As the blow of ſo light a mallet cannot bring much ſound from a wire, it has always been found neceſſary to have two ſtrings for each note. Another circumſtance contributes to enfeeble the ſound. The mechaniſm neceſſary for producing it makes it almoſt impoſſible to give any conſiderable extent to the belly or ſound board of the inſtrument. There is ſeldom any more of it than what occupies the ſpace between the tuning pins and the bridge. This is the more to be regretted, becauſe the baſſes are commonly covered ſtrings, that they may be of a moderate length. The baſs notes are alſo of braſs, which has a conſiderably lower tone than a ſteel wire of the ſame diameter and tenſion. Yet even this ſubſtitution for ſteel in the baſs ſtrings is not enough. The higheſt of them are much too ſlack, and the loweſt ones muſt be loaded, to compenſate for want of length. This greatly diminiſhes the fulneſs, and ſtill more the mellowneſs and diſtinctneſs of the tone, and frequently makes the very loweſt notes hardly appreciable. This inequality of tone about the middle of the inſtrument is ſomewhat diminiſhed by conſtructing the inſtrument with two bridges; one for the ſteel, and the other for the braſs wires. But ſtill the

Piano Forte

the bafs notes are very much inferior to the treble. It would furely be worth while to conftruct fome piano fortes, of full fize, with naked baffes. If thefe were made with all the other advantages of the grand piano forte, they would furpafs all other inftruments for the regulating power of their thorough bafs. We wifh that the artifts would alfo try to conftruct them with the mechanifm of mallets, &c. above the found board. This would allow to it the full extent of the inftrument, and greatly improve the tone. It does not feem impoffible, nor (we think) very difficult.

For directions how to tune this pleafing inftrument, fee TEMPERAMENT in this *Supplement*.

PIGMENTS, or PAINTS, are furnifhed by both the mineral and vegetable kingdoms. The former are the moft durable, and are generally prepared from the OXYDS of metals (fee CHEMISTRY-*Index* in this *Suppl.* and *Colour-Making*, Encycl.); but Fourcroy thinks that chemiftry furnifhes a method of fixing vegetable colours completely. From a number of experiments, which we need not detail, as they will be noticed in the article *Vegetable* SUBSTANCES, he draws the following conclufions:

1. That oxygen, when combined with vegetable fubftances, changes their colour.

2. That different proportions of this principle produce different fhades in coloured vegetable matter.

3. That thefe fhades pafs, by a fort of degradation, from the darkeft colours to the lighteft; and that the extreme point of the latter may be confidered as a complete deprivation of colour.

4. That in many vegetable fubftances this degradation does not take place, as M. Berthollet has obferved.

5. That many red, violet, purple, chefnut, and blue vegetable colours, are produced by different proportions of oxygen; but that none of thefe are completely faturated with this principle.

6. That the complete faturation here fpoken of generally produces yellow colours, which are the leaft changeable of all.

7. That vegetable fubftances coloured by oxygen, not only change their colour according to the proportion of oxygen they have imbibed, but that they alfo change their nature in the fame proportion, and approach more to a refinous ftate as they become nearer to a yellow colour.

Laftly, that the caufe of the changeability of the red, brown, and violet colours, procured from vegetables, is fuch as has been ftated above; that there exifts a method of fixing them, or rendering them permanent, by impregnating them with a certain quantity of oxygen, by means of the oxygenated muriatic acid; imitating, by this procefs, the method purfued by nature, who never forms fixed and permanent colours, except in fubftances which have been long expofed to the open air.

PITCH. See *Encycl.*—The beft black pitch is made of the refufe of rofin and turpentine, fuch as will not pafs through the ftraw filter, and the cuttings around the incifion on the tree. Thefe materials are put into a boiler fix or feven feet in circumference, and eight or ten high. Fuel is laid around the top, and the materials as they melt flow through a channel cut in the fire-place into a tub half filled with water. It is at that time very red, and almoft liquid. To give this a proper confiftence, it is put in a cauldron placed in a furnace, and boiled down in the fame manner as rofin, but it requires much lefs precaution and double the time. It is then poured into moulds of earth, and forms the beft kind of black pitch. See ROSIN and TURPENTINE in this *Suppl.*

BASTARD PITCH, is a mixture of colophony, black pitch, and tar. They are boiled down together, and put into barrels of pine wood, forming, when the ingredients are mixed in equal portions, a fubftance of a very liquid confiftence, called in France *bray gras*. If, on the contrary, it is defired of a thicker confiftence, a greater proportion of colophony is added, and it is caft in moulds. It is then called *baftard pitch*.

PLAGUE (fee MEDICINE-*Index*, Encycl.), is a difeafe which has been lately afferted by Dr Mofeley to be not contagious. In fupport of this opinion, he quotes many paffages from medical writers, ancient and modern; but he feems to place the greateft confidence (as is indeed natural) in his own obfervations on peftilential fevers in the Weft Indies, and on what is faid of the plague in Berthier's account of Buonaparte's expedition into Syria.

"At [illegible] (fays this Frenchman), [illegible] a malady [illegible] in the [illegible] felves up [illegible] every [illegible] have [illegible]

"Citizen De[illegible] phyfician to the army, [illegible] entitle him to [illegible] were attacked [illegible] had [illegible] founded [illegible] by the officers [illegible] Citizen Degenettes [illegible] vifited all the patients, felt the [illegible] fwellings, dreffed them, declared and maintained that the diftemper was not the plague, but a malignant fever with glandular fwellings, which might eafily be cured by attention, and keeping the patient's mind eafy."

Degenette's views in making this diftinction were highly commendable; but certainly, fays Dr Mofeley, this fever was the plague. The phyfician, however, carried his courage fo far, as to make two incifions, and to inoculate the fuppurated matter from one of thefe buboes above his breaft and under his arm-pits, but was not affected with the malady. He thus eafed the minds of the foldiers, the firft ftep to a cure; and, by his affiduity and conftant attendance in the hofpitals, a number of men attacked with the plague were cured. His example was followed by other officers of health.

The lives of a number of men Citizen Degenettes was

(A) This can hardly be true. Every one knows that Mahometans are fatalifts in the ftricteft fenfe of the word; and Mr Browne, whofe knowledge of Syria and its inhabitants muft be at leaft equal to that of Berthier, affures us, that, far from abandoning his friend in the plague, "the Moflem, awe-ftruck, and refigned to the unalterable decrees of fate, hangs over the couch of his expiring relative."

Plague.

was thus inftrumental of faving. He difmiffed thofe who had been ill with the fever and buboes, without the leaft contagion being communicated to the army.

"There are (fays Dr Mofeley) annual or feafonal diforders, more or lefs fevere, in all countries; but the plague, and other great depopulating epidemics, do not always obey the feafons of the year. Like comets, their courfe is eccentric. They have their revolutions; but from whence they come, or whither they go after they have made their revolutions, no mortal can tell.

"To look for the caufe of an epidemic in the prefent ftate of the air, or weather, when it makes its appearance, is a very narrow contracted method of fcrutiny. The caufe of peftilential epidemics cannnot be confined, and local. It muft lie in the atmofphere, which furrounds, and is in contact with every part of us; and in which we are immerfed, as bodies in fluids.

"Thefe difeafes not appearing in villages and thinly inhabited places, and generally attacking only great towns and cities, may be, that the atmofphere, which I conceive to be the univerfal propagator of peftilence, wants a commixture, or union, with fome compounded and peculiar air, fuch as is generated in populous communities, to releafe its imprifoned virulence, and give it force. Like the divided feminal principles of many plants, concealed in winds and rains until they find fuitable materials and foil to unite their feperated atoms, they then affume vifible forms in their own proper vegetation.

"Difeafes originating in the atmofphere feize fome, and pafs by others; and act exclufively on bodies graduated to receive their impreffions; otherwife whole nations would be deftroyed. In fome conftitutions of the body the accefs is eafy, in fome difficult, and in others impoffible.

"The air of confined places may be fo vitiated as to be unfit for the purpofes of the healthy exiftence of any perfon. Hence gaol, hofpital, and fhip fevers. But as thefe diftempers are the offspring of a local caufe, that local caufe, and not the diftempered people, communicate the difeafe.

"Plagues and peftilences, the produce of the great atmofphere, are conveyed in the fame manner, by the body being in contact with the caufe; and not by its being in contact with the effect. If peftilences were propagated by contagion, from infected perfons, the infection muft iffue from their breath or excrements, or from the exhalations of the bodies of the difeafed. The infection, if it were not in the atmofphere, would be confined within very narrow limits; have a determinate fphere of action; and none but phyficians and attendants on the fick would fuffer; and thefe muft fuffer; and the caufe and the effects would be palpable to our fenfes. Upon this ground the precaution of quarantine would be rational. But who then would vifit and attend the fick, or could live in hofpitals, prifons, and lazarettos?"

From thefe reafonings and facts, the author is convinced, that the bubo and carbuncle, of which we hear fo much in Turkey, and read fo much in our own hiftory of plagues, arife from heating food and improper treatment; that they contain no infection; and confequently that they are not the natural depofit of the morbific virus feparated from the contagion.

He is equally confident that no peftilential or pandemic fever was ever imported or exported; and hence he confiders the fumigating of fhip-letters, and fhutting up the crews and paffengers of veffels, on their arrival from foreign places, feveral weeks, for fear they fhould give difeafes to others which they have not themfelves, as an ignorant barbarous cuftom. Whence was the importation of the plague at Naples in 1656; by which 20,000 people died in one day? Can any perfon, for a moment reflecting, believe, that the great plague of London in 1665, which imagination traced from the Levant to Holland, and from Holland to England, was caufed by opening a bag of cotton in the city, or in Long Acre; or a package of hemp in St Giles's parifh? Quarantine, always expenfive to commerce, and often ruinous to individuals, is a reflection on the good fenfe of countries.

That Dr Mofeley is a man of learning, and a lively writer, is known to every one who has looked into his works, and is not himfelf a ftranger to letters. On this account, and ftill more on account of the opportunities which he has poffeffed of making accurate obfervations on various kinds of peftilential difeafes, we have detailed at fome length his notions of the plague; but as it does not appear that he ever *faw* the difeafe which is *known* by the name of *the plague*, juftice requires that we give fome account of it from a man who had the beft poffible opportunities of obtaining correct information on the fubject.

"The facts that appear to be chiefly afcertained relative to the plague (fays Mr Browne), are, 1. That the infection is not received but by actual contact. In this particular, it would feem lefs formidable than feveral other diforders. 2. That it is communicated by certain fubftances, by others not; as by a woollen cloth, or rope of hemp, but not by a piece of ivory, wood, or a rope made of the date tree; nor by any thing that has been completely immerfed in water. It would appear from the report of the Kahirines*, that no animal but man is affected with this diforder; though, it is faid, a cat paffing from an infected houfe has carried the contagion. 3. That perfons have often remained together in the fame houfe, and entirely under the fame circumftances, of whom one has been attacked and died, and the others never felt the fmalleft inconvenience. 4. That a perfon may be affected any number of times. 5. That it is more fatal to the young than the old 6. That no climate appears to be exempt from it; yet, 7. That the extremes of heat and cold both appear to be adverfe to it. In Conftantinople it is often, but far from being always, terminated by the cold of winter, and in Kahira by the heat of fummer; both circumftances being, as may be conjectured, the effect of indifpofition for abforption in the fkin, unlefs it be fuppofed that in the latter cafe it may be attributed to the change the air undergoes from the increafe of the Nile.

"The firft fymptoms are faid to be thirft; 2. cephalalgia; 3. a ftiff and uneafy fenfation, with rednefs and tumor about the eyes; 4. watering of the eyes; 5. White puftules on the tongue The more advanced fymptoms of buboes, fœtor of the breath, &c. &c. are well known; and I have nothing authentic to add to them. Not uncommonly, all thefe have fucceffively fhewn themfelves, yet the patient has recovered; in which cafe, where fuppuration has had place, the fkin always remains difcoloured, commonly of a purple hue. Many who have been bleeded in an early ftage of the diforder,

* The inhabitants of Cairo, which Mr Browne uniformly calls Kahira.

disorder, have recovered without any fatal symptoms; but whether from that or any other cause, does not appear certain (B). The same operation is reported to have been commonly fatal in a late stage. It is said that embrocating the buboes continually with oil has sometimes wrought a cure; but this remedy is so difficult and dangerous for the operator, that it would appear experiments must yet be very defective"

They are not, perhaps, so defective as Mr Browne supposes. In the hospital of St Anthony at Smyrna, it has been the practice for many years past to rub over with warm olive oil the bodies of persons infected by the plague; and that practice has been attended with wonderful success. It was first suggested by Mr Baldwin the English consul; and from him adopted by *P. Luigi di Pavia*, who for upwards of 27 years has exposed himself to infection by his unremitting attendance on those who are labouring under this dreadful distress. This excellent man, whose philanthropy equals that even of "Marseilles' good bishop," declares, that during the long period mentioned, he has found no remedy comparable to that of rubbing olive oil, with the strongest friction, into the whole body of the infected person. When the body is thus rubbed, the pores being opened, imbibe the oil, and a profuse perspiration takes place, by which the poisonous infection is again thrown out. This operation must be performed the first day of the infection; and if only a weak perspiration ensues, it must be repeated till it is observed that every particle of infection is removed, and that the whole body of the patient is covered with a profuse sweat. Neither the patient's shirt nor bed-clothes must be changed till the perspiration has entirely ceased. The operation must be performed in a very close apartment; and at every season of the year there must be kept in it a fire-pan, over which sugar and juniper must be thrown from time to time, that the vapour which thence arises may promote the perspiration. The whole body of the patient, the eyes alone excepted, must in this manner be anointed, or rather rubbed over with the greatest care.

This practice of the pious monk is mentioned by Mr Howard in his work on Lazarettos; but a more satisfactory account of it is given by Count *Leopold von Berchtold*, who adds the following remarks by way of illustration: 1. The operation of rubbing in the oil must be performed by means of a sponge, and so speedily as not to last more than about three minutes. 2. The interval between the first and the second rubbing, if a second be necessary, must be determined by circumstances, as the second must not be performed till the first perspiration is over, and this will depend on the constitution of the patient. If any sweat remains upon the skin, it must be wiped off with a warm cloth before the second rubbing takes place. This strong friction with oil may be continued, for several days successively, until a favourable change is remarked in the disease; after which the rubbing may be performed in a more gentle manner. The quantity of oil requisite each time cannot be determined with accuracy; but, in general, a pound may be sufficient. The purest and freshest oil is the best for this operation: it must not be hot, but only lukewarm. The breast and privities must be rubbed softly. In a cold climate such as ours, those parts only into which the oil is rubbed must be exposed naked. The other parts must be covered with warm clothing. In this manner each part of the body must be rubbed with oil in succession, as quickly as possible, and be then instantly covered. If the patient has boils or buboes, they must be rubbed over gently with the oil till they can be brought to suppurate by means of emollient plasters. The persons who attend the patients to rub in the oil must take the precaution to rub themselves over in the like manner, before they engage in the operation. They must, if possible, avoid the breath of the patient, and not be under any apprehensions of catching the infection.

P. Luigi then says, "In order to prevent the patients from losing their strength, I prescribed for them, during four or five days, soup made of vermicelli boiled in vinegar without salt. I gave them six or seven times a-day a small spoonful of preserved sour cherries; preserved not with honey, but with sugar, as the former might have occasioned a diarrhoea. When convinced that the patients were getting better, I usually gave them the fifth morning a cup of good Mocha coffee, with a piece of toasted biscuit (*biscotto*) prepared with sugar; and I doubled the latter according to the strength and improvement of my patients."

In the course of five years, during which friction with oil was employed in the hospital at Smyrna, of 250 persons attacked by the plague the greater part were

(B) Dr Mosely, we think, has assigned a very sufficient reason why bleeding should generally prove effectual, if recourse be had to it at the commencement of the disease. "In the common order of pestilential fevers (says he), they commence with coldness and shivering; simply demonstrating, that something unusual has been in contact with the skin, agonizing cutaneous sensibility. Sickness at the stomach, and an immoveable pressure about the præcordia, follow. These demonstrate, that the blood cannot pervade the extremities of the body, and that the quantity which ought to dilate through the whole machine is confined to the larger organs, and is crowding and distending the heart and central vessels.

"The restraining power of the remoter blood-vessels being destroyed, the thinner parts of the blood escape their boundaries; hence arises yellowness in the skin in some climates; in others, the extravasated grosser parts of the blood stagnate, forming black lodgements, bubo, anthrax, and exanthemata.

"The object in these fevers is, to decide the contest between the solids and the fluids; and this appears to me to be only practicable, when spontaneous sweats do not happily appear, or cannot be raised by a cooling regimen; and by draining the vital parts, by bleeding and purging, before the fluids have burst their confines, and dissolved their bond of union with the solids. The next step is to regain the lost energy of the surface of the body, by exciting perspiration; and then of the whole system, by tonics.

"When these things are not done in the first hours of attack, in pestilential fevers, and the conflict is not *extinguished* at once, attempting to extort sweats from the body, by heating alexapharmics, will do mischief; and bark, wine, stimulants, and cordials, may be called on, like undertakers, to perform an useless ceremony."

Plague, Plants.

were cured; and this would have been the case with the rest had they not neglected the operation, or had it not been employed too late after their nervous system had been weakened by the disease so as to render them incurable. Immense numbers of people have been preserved from the effects of this malady by the above means; and of all those who have anointed themselves with oil, and rubbed it well into their bodies, not one has been attacked by the plague, even though they approached persons already infected, provided they abstained from heavy and indigestible food.

Thus we see, if this account may be depended on, that oil rubbed into the skin acts as a preventative, as well as a cure. When the operation is performed to prevent infection, and it is successfully performed with that view at Smyrna, as often as the plague makes its appearance in the city, as it is not done for the purpose of promoting perspiration, it is not requisite that it should be performed with the same speed as when for curing the disorder; nor is it necessary to abstain from flesh and to use soups; but it will be proper to use only fowls or veal for ten or twelve days, boiled or roasted, without any addition or seasoning *(condimento)*. In the last place, it will be necessary to guard against fat and indigestible food, and such liquors as might put in motion or inflame the mass of the blood.

This important discovery deserves the serious consideration of all medical men; for if olive oil has been found efficacious in curing or preserving against one species of infection, it is not absurd to suppose that the same or other kinds of oil might be productive of much benefit in other malignant infectious diseases. We hope soon to hear of some trial being made with it in this country. Would it be of any service in the yellow fever, so prevalent in the western world? See the *Philosophical Magazine*, Vol. II.

PLANETARY HOURS, are twelfth parts of the artificial day and night; being each double in length to the hour used in civil computation in Europe. They are still used by the Jews as they were among their forefathers; and hence are called Jewish hours. The reason of their being called *planetary* hours, is that, according to the astrologers, a new planet comes to predominate every hour, and that the day takes its denomination from that which predominates the first hour of it; as Monday from the moon, &c.

PLANTS, organised bodies, of which a full account has been given in the *Encycl.* under the title BOTANY, PLANT, SEXES, *&c.* The establishment of the sexual system in vegetables, and the acknowledged analogy between vegetable and animal bodies, has suggested a method of improving plants, as animals are confessedly improved, by what is called *crossing the breed*. This thought occurred first, we believe, to Andrew Knight, Esq; and in the Transactions of the Royal Society for 1799, we have an account of some very curious experiments made by him, with the view of ascertaining whether the improvement which he had conceived be actually practicable. Those were chiefly made on the garden pea, of which he had a kind growing in his yard; which having been long cultivated in the same soil, had ceased to be productive, and did not appear to recover the whole of its former vigour when removed to a soil of a somewhat different quality. On this his first experiment in 1787 was made. Having opened a dozen of its immature blossoms, he destroyed the male parts, taking great care not to injure the female ones; and a few days afterwards, when the blossoms appeared mature, he introduced the farina of a very large and luxuriant grey pea into one half of the blossoms, leaving the other half as they were. The pods of each grew equally well; but he soon perceived that of those into whose blossoms the farina had not been introduced, the seed remained nearly as they were before the blossom expanded, and in that state they withered. Those in the other pods attained maturity, but were not in any sensible degree different from those afforded by other plants of the same variety; owing, he imagines, to the external covering of the seed (as he had found in other plants) being furnished entirely by the female. In the succeeding spring, the difference, however, became extremely obvious; for the plants from them arose with excessive luxuriance, and the colour of their leaves and stems clearly indicated that they had all exchanged their whiteness for the colour of the male parent: the seeds produced in autumn were dark grey. By introducing the farina of another white variety (or in some instances by simple culture), he found this colour was easily discharged, and a numerous variety of new kinds produced; many of which were in size and every other respect much superior to the original white kind, and grew with excessive luxuriance, some of them attaining the height of more than twelve feet.

The dissimilarity he observed in the offspring, afforded by different kinds of farina in these experiments, pointed out to him an easy method of ascertaining whether superfœtation (the existence of which has been admitted among animals) could also take place in the vegetable world. For as the offspring of a white pea is always white, unless the farina of a coloured kind be introduced into the blossom, and as the colour of the grey one is always transferred to its offspring, though the female be white, it readily occurred to Mr Knight, that if the farina of both were mingled or applied at the same moment, the offspring of each could be easily distinguished.

His first experiment was not altogether successful; for the offspring of five pods (the whole which escaped the birds) received their colour from the coloured male. There was, however, a strong resemblance to the other male in the growth and character of more than one of the plants; and the seeds of several in the autumn very closely resembled it in every thing but colour. In this experiment he used the farina of a white pea, which possessed the remarkable property of shrivelling excessively when ripe; and in the second year he obtained white seeds from the grey ones above mentioned, perfectly similar to it. He is therefore strongly disposed to believe that the seeds were here of common parentage; but doth not conceive himself to be in possession of facts sufficient to enable him to speak with decision on this question. We have no right to form a decided opinion on this part of the subject, having paid to it very little attention; but at present we are inclined to think differently from the author. We admit, indeed, that if the female afford the first organized atom, and the male act only as a stimulus, it is by no means impossible that the explosion of two vesicles of farina, at the same moment (taken from different plants), may afford seeds of common parentage; but whether the female or the male affords the first organized atom, is the question which to us appears not yet decided.

Another ſpecies, however, of ſuperfœtation, in which one ſeed appears to have been the offspring of two males, has occurred to Mr Knight ſo often, as to remove, he ſays, all poſſibility of doubt as to its exiſtence. In 1797, the year after he had ſeen the reſult of the laſt mentioned experiment, having prepared a great many white bloſſoms, he introduced the farina of a white and that of a grey nearly at the ſame moment into each; and as in the laſt year the character of the coloured male had prevailed, he uſed its farina more ſparingly than that of the white one; and now almoſt every pod afforded plants of different colours. The majority, however, were white; but the characters of the two kinds were not ſufficiently diſtinct to allow him to judge with preciſion whether any of the ſeeds were produced of common parentage or not. In the year 1798 he was more fortunate; having prepared bloſſoms of the little early frame pea, he introduced its own farina, and immediately afterwards that of a very large and late grey kind, and ſowed the ſeeds thus obtained in the end of ſummer. Many of them retained the colour and character of the ſmall early pea, not in the ſlighteſt degree altered, and bloſſomed before they were eighteen inches high; whilſt others (taken from the ſame pods), whoſe colour was changed, grew to the height of more than four feet, and were killed by the froſt before any bloſſoms appeared.

It is evident, that in theſe inſtances ſuperfœtation took place; and it is equally evident that the ſeeds were not all of common parentage. Should ſubſequent experience evince, that a ſingle plant may be the offſpring of two males, the analogy between animal and vegetable nature may induce ſome curious conjectures relative to the proceſs of generation in the animal world.—It certainly may; but either we do not perfectly underſtand the author's meaning, or this experiment is not concluſive. There were here ſeeds of different colours produced by the farina of different males, operating on the ſame female plant; and there are well atteſted inſtances of twin children being born of different colours, in conſequence of the coition of different males, a negro and a white man, with the ſame woman. Had Mr Knight diſcovered, not that the ſame pod, but that the ſame individual *pea*, was the offſpring of two males, his diſcovery would indeed have led to ſome curious conjectures reſpecting animal generation. But to proceed with his experiments:

By introducing the farina of the largeſt and moſt luxuriant kinds into the bloſſoms of the moſt diminutive, and by reverſing this proceſs, he found that the powers of the male and female, in their effects on the offſpring, are exactly equal. The vigour of the growth, the ſize of the ſeeds produced, and the ſeaſon of maturity, were the ſame, though the one was a very early and the other a late variety. He had in this experiment a ſtriking inſtance of the ſtimulative effects of croſſing the breeds; for the ſmalleſt variety, whoſe height rarely exceeded two feet, was increaſed to ſix feet; whilſt the height of the large and luxuriant kind was very little diminiſhed. By this proceſs it is evident, that any number of new varieties may be obtained; and it is highly probable, that many of theſe will be found better calculated to correct the defects of different ſoils and ſituations than any we have at preſent.

The ſucceſs of Mr Knight's experiments on the pea induced him to make ſimilar experiments on wheat; but theſe did not anſwer his expectations. The varieties indeed which he obtained, eſcaped the blights of 1795 and 1796; but their qualities were not otherwiſe good, nor were they permanent. His experiments on the apple, the improvement of which was the firſt object of his attention, have, as far as he could judge from the cultivated appearance of trees which had not borne fruit when he wrote his memoir, been fully equal to his hopes. The plants which he obtained from his efforts to unite the good qualities of two kinds of apple, ſeem to poſſeſs the greateſt health and luxuriance of growth, as well as the moſt promiſing appearance in other reſpects. In ſome of theſe the character of the male appears to prevail; in others that of the female; and in others both appear blended, or neither is diſtinguiſhable. Theſe variations, which were often obſervable in the ſeeds taken from a ſingle apple, evidently ariſe from the want of permanence in the character of this fruit, when raiſed from ſeed. Many experiments of the ſame kind were tried on other plants; but it is ſufficient to ſay, that all tended to evince, that improved varieties of every fruit and of eſculent plants may be obtained by this proceſs, and that Nature intended that a ſexual intercourſe ſhould take place between neighbouring plants of the ſame ſpecies.

Plants, Nutrition of. This is a ſubject on which a variety of opinions has been entertained by modern chemiſts. Haſſenfratz conſiders carbon as the ſubſtance which nouriſhes vegetables. Ingenhouſz, in his work on the nutrition of plants, publiſhed in 1797, endeavours to prove, that if carbon has any influence in this reſpect, it can be only in the ſtate of carbonic acid, as that acid is abſorbed and decompoſed by vegetables; while the ligneous carbon, furniſhed by Nature, produces no effect on the [illegible] plants. Mr A. Young has endeavoured to [illegible] the ſame thing by experiments. Mr Rafn, a Daniſh chemiſt, deſirous of diſcovering [illegible] theſe contradictory opinions, [illegible] years, a ſeries of experiments, from [illegible] by the vegetation, ſize, and colour of [illegible] that carbon, either vegetable or [illegible] a decided influence in the nouriſhment of vegetables. What is new, and particularly worthy of remark in theſe reſearches, is, that, according to Mr Rafn, the carbonic acid produces exactly the ſame effect as charcoal of wood.

According to Mr Rafn, coal aſhes, on which the German and Engliſh farmers beſtow ſuch praiſe, deſtroy the plants if the ſoil contains an eighth part of that admixture. The leaves become faded, as if ſcorched, at the end of from fifteen to twenty days, and the plants themſelves die at the end of four or five weeks.

No ſeed germinates in oil. A ſingle grain of common ſalt, in 200 grains of water, is ſufficient to retard the vegetation of plants, and may even kill them if they are watered with that ſaline liquor.

Shavings of horn, next to infuſion animals, are the moſt favourable to vegetation: charcoal holds the third rank. For the truth of theſe opinions, ſee *Vegetable Substances* in this *Suppl.*

PLATINUM, or Platina (See Chemistry, *Suppl.* Part I. Chap. iii. Sect. 3.), is a metal, of which every chemiſt regrets the difficulty of making it malleable. Of the different proceſſes adopted to accompliſh this end, we have reaſon to believe that of Mr Richard Knight the moſt ſucceſsful; and, with the ſpirit

spirit of a true philosopher, he wishes to make that process as generally known, as possible. We shall give it in his own words:

"To a given quantity of crude platinum, I add (says he) 15 times its weight of nitro-muriatic acid (composed of equal parts of nitric and muriatic acids) in a tubulated glass retort, with a tubulated receiver adapted to it. It is then boiled, by means of an Argand's lamp, till the acid has assumed a deep saffron colour: it is then poured off; and if any platina remains undissolved, more acid is added, and it is again boiled until the whole is taken up. The liquor, being suffered to rest till quite clear, is again decanted: a solution of sal-ammoniac is then added, by little and little, till it no longer gives a cloudiness. By this means the platina is thrown down in the form of a lemon-coloured precipitate, which having subsided, the liquor is poured off, and the precipitate repeatedly washed with distilled water till it ceases to give an acid taste (too much water is injurious, the precipitate being in a certain degree soluble in that liquid); the water is then poured off, and the precipitate evaporated to dryness."

Thus far our author's method, as he candidly observes himself, differs not from that which has been followed by many others; but the remainder of the process is his own. "A strong, hollow, inverted cone of crucible earth being procured, with a corresponding stopper to fit it, made of the same materials, the point of the latter is cut off about three-fourths from the base. The platina, now in the state of a light yellow powder, is pressed tight into the cone, and a cover being fixed slightly on, it is placed in an air-furnace, and the fire raised gradually to a strong white heat. (The furnace used by Mr Knight is portable, with a chamber for the fire only eight inches in diameter.) In the mean time the conical stopper, fixed in a pair of iron tongs suitable for the purpose, is brought to a red, or to a bright white heat. The cover being then removed from the cone, the point of the heated stopper is introduced [illegible] of the furnace, and pressed at first gently on the platina, at this time in a state nearly as soft as dough, till it at length acquires a more solid consistence. It is then repeatedly struck with the stopper, as hard as the nature of the materials will admit, till it [illegible] to receive no farther impression. The cone is then removed from the furnace; and being struck lightly with a hammer, the platina falls out in a metallic button, from which state it may be drawn, by repeatedly heating and gently hammering, into a bar fit for flatting, drawing into wire, planishing, &c.

"Besides the comparative facility of this process, it has the farther advantage of rendering the platina much purer than when red-hot iron is obliged to be had recourse to; for platina, when of a white heat, has a strong affinity for iron, and, with whatever care it may have been previously separated from that metal, will be found to have taken up a portion of it, when it is employed of a red heat, to serve to unite the particles of the platina."

PLATONIC Bodies, see *Regular Bodies, Suppl.*

PLUVIAMETER, a machine for measuring the quantity of rain that falls, otherwise called Ombrometer; which see, *Encycl.*

POLLARDS, the name of a coarse kind of wheaten flour. When the flour of wheat is separated into three degrees of fineness, the third is the pollards. There is nothing between it and the bran.

PORCELAIN, a kind of earthen or stone ware, of the manufacture of which a full account is given in the *Encyclopædia* from Grosier and Reaumur. It may be proper, however, to add here, from Sir George Staunton, that one of the principal ingredients in the Chinese porcelain called *pe-tun-tse*, is a species of fine granite, or compound of quartz, feldspath, and mica, in which the quartz bears the largest proportion. "It appears (says Sir George) from several experiments, that *pe-tun-tse* is the same as the growan-stone of the Cornish miners. The micaceous part in some of this granite from both countries, often contains some particles of iron; in which case it will not answer the potter's purpose. This material can be calcined and ground much finer by the improved mills of England, than by the very imperfect machinery of the Chinese, and at a cheaper rate, than the prepared *pe tun-tse* of their own country, notwithstanding the cheapness of labour there. The *kao-lin*, or principal matter mixed with the *pe-tun-tse*, is the growan clay also of the Cornish miners. The *wha-she* of the Chinese is the English soap rock, and the *she-kao* is asserted to be gypsum.

"The manufacture of porcelain is said to be precarious from the want of some precise method of ascertaining and regulating the heat within the furnaces, in consequence of which, their whole contents are baked sometimes into one solid and useless mass." If this be so, Wedgewood's thermometer would be a present highly valuable to the Chinese potter, if that arrogant and conceited people would condescend to be taught by a native of Europe.

POSITION, Centre of, is a point of any body, or system of bodies, so selected, that we can estimate with propriety the situation and motion of the body or system by the situation and motion of this point. It is very plain that, in all our attempts to accurate discussion of mechanical questions, especially in the present extended sense of the word *mechanism*, such a selection is necessary. Even in common conversation, we frequently find it necessary to ascertain the distance of objects with a certain precision, and we then perceive that we must make some such selection. We conceive the distance to be mentioned, neither with respect to the nearest nor the remotest point of the object, but as a sort of average distance; and we conceive the point so ascertained to be somewhere about the middle of the object. The more we reflect on this, we find it the more necessary to attend to many circumstances which we had overlooked. Were it the question, to decide in what precise part of a country parish the church should be placed, we find that the geometrical middle is not always the most proper. We must consider the populousness of the different quarters of the parish, and select a point such, that the distances of the inhabitants on each side, in every direction, shall be as equally balanced as possible.

In mechanical discussions, the point by whose position and distance we estimate the position and distance of the whole, must be so selected, that its position and distance, estimated in any direction whatever, shall be the average of the positions and distances of every particle of the assemblage, estimated in that direction.

This will be the case, if the point be so selected that, when a plane is made to pass through it *in any direction*

Position. *tion whatever*, and perpendiculars are drawn to this plane from every particle in the body or system, the sum of all the perpendiculars on one side of this plane is equal to the sum of all the perpendiculars on the other side. If there be such a point in a body, the position and motion of this point is the average of the positions and motions of all the particles.

Plate XL. For if P (fig. 1.) be a point so situated, and if QR be a plane (perpendicular to the paper) at any distance from it, the distance P*p* of the point from this plane is the average of the distances of all the particles from it. For let the plane APB be passed through P, parallel to QR. The distance CS of any particle C from the plane QR is equal to DS−DC, or to P*p*—DC. And the distance GT of any particle G lying on the other side of APB, is equal to HT+GH, or to P*p*+GH. Let *n* be the number of particles on that side of AB which is nearest to QR, and let *o* be the number of those on the remote side of AB, and let *m* be the number of particles in the whole body, and therefore equal to $n+o$. It is evident that the sum of the distances of all the particles, such as C, is *n* times P*p*, after deducting all the distances, such as DC. Also the sum of all the distances of the particles, such as G, is *o* times P*p*, together with the sum of all the distances, such as GH. Therefore the sum of both sets is $\overline{n+o} \times \mathrm{P}p +$ sum of GH — sum of DC, or $m \times \mathrm{P}p +$ sum of GH — sum of DC. But the sum of GH, wanting the sum of DC, is nothing, by the supposed property of the point P. Therefore $m \times \mathrm{P}p$ is the sum of all the distances, and P*p* is the *m*th part of this sum, or the average distance.

Now suppose that the body has changed both its place and its position with respect to the plane QR, and that P (fig. 2.) is still the same point of the body, and π P 3 a plane parallel to QR. Make $p\,\pi$ equal to *p* P of fig. 1. It is plain that P*p* is still the average distance, and that $m \times \mathrm{P}p$ is the sum of all the present distances of the particles from QR, and that $m \times \pi p$ is the sum of all the former distances. Therefore $m \times \mathrm{P}\pi$ is the sum of all the changes of distance, or the whole quantity of motion estimated in the direction π P. Pπ is the *m*th part of this sum, and is therefore the average motion in this direction. The point P has therefore been properly selected; and its position, and distance, and motion, in respect of any plane, is a proper representation of the situation and motion of the whole.

It follows from the preceding discussion, that if any particle C (fig. 1.) moves from C to N, in the line CS, the centre of the whole will be transferred from P to Q, so that PQ is the *m*th part of CN; for the sum of all the distances has been diminished by the quantity CN, and therefore the average distance must be diminished by the *m*th part of CN, or PQ is $= \frac{\mathrm{CN}}{m}$.

But it may be doubted whether there is in every body a point, and but one point, such that if a plane pass through it, *in any direction whatever*, the sum of all the distances of the particles on one side of this plane is equal to the sum of all the distances on the other.

It is easy to shew that such a point may be found, with respect to a plane parallel to QR. For if the sum of all the distances DC exceed the sum of all the distances GH, we have only to pass the plane AB a little nearer to QR, but still parallel to it. This will diminish the sum of the lines DC, and increase the sum of the lines GH. We may do this till the sums are equal.

In like manner we can do this with respect to a plane LM (also perpendicular to the paper), perpendicular to the plane AB. The point wanted is somewhere in the plane AB, and somewhere in the plane LM. Therefore it is somewhere in the line in which these two planes intersect each other. This line passes through the point P of the paper where the two lines AB and LM cut each other. These two lines represent planes, but are, in fact, only the intersection of those planes with the plane of the paper. Part of the body must be conceived as being above the paper, and part of it behind or below the paper. The plane of the paper therefore divides the body into two parts. It may be so situated, therefore, that the sum of all the distances from it to the particles lying above it shall be equal to the sum of all the distances of those which are below it. Therefore the situation of the point P is now determined, namely, at the common intersection of three planes perpendicular to each other. It is evident that this point alone can have the condition required in respect of these three planes.

But it still remains to be determined whether the same condition will hold true for the point thus found, in respect to *any other* plane passing through it; that is, whether the sum of all the perpendiculars on one side of *this fourth* plane is equal to the sum of all the perpendiculars on the other side. Therefore

Let AGHB (fig. 3.), AXYB, and CDFE, be three planes intersecting each other perpendicularly in the point C; and let CIKL be any other plane, intersecting the first in the line CI, and the second in the line CL. Let P be any particle of matter in the body or system. Draw PM, PO, PR, perpendicular to the first three planes respectively, and let PR, when produced, meet the oblique plane in V; draw MN, ON, perpendicular to CE. They will meet in one point N. Then PMNO is a rectangular parallelogram. Also draw NQ perpendicular to CE, and therefore parallel to AB, and meeting CI in S. Draw SV; also draw ST perpendicular to VP. It is evident that SV is parallel to CL, and that STRQ and STPM are rectangles.

All the perpendiculars, such as PR, on one side of the plane CDFE, being equal to all those on the other side, they may be considered as compensating each other; the one being considered as positive or additive quantities, the other are negative or subtractive. There is no difference between their sums, and the sum of both sets may be called o or nothing. The same must be affirmed of all the perpendiculars PM, and of all the perpendiculars PO.

Every line, such as RT, or its equal QS, is in a certain invariable ratio to its corresponding QC, or its equal PO. Therefore the positive lines RT are compensated by the negative, and the sum total is nothing.

Every line, such as TV, is in a certain invariable ratio to its corresponding ST, or its equal PM, and therefore their sum total is nothing.

Therefore the sum of all the lines PV is nothing; but each is in an invariable ratio to a corresponding perpendicular from P on the oblique plane CIKL. Therefore the sum of all the positive perpendiculars on this plane is equal to the sum of all the negative perpendiculars, and the proposition is demonstrated, viz. that

in

in every body, or system of bodies, there is a point such. that if a plane be passed through it *in any direction whatever*, the sum of all the perpendiculars on one side of the plane is equal to the sum of all the perpendiculars on the other side.

The point P, thus selected, may, with great propriety, be called the CENTRE OF POSITION of the body or system.

If A and B (fig. 4.) be the centres of position of two bodies, whose quantities of matter (or numbers of equal particles) are a and b, the centre C lies in the straight line joining A and B, and $AC : CB = b : a$, or its distance from the centres of each are inversely as their quantities of matter. For let $\alpha C \beta$ be any plane passing through C. Draw $A\alpha$, $B\beta$, perpendicular to this plane. Then we have $a \times A\alpha = b \times B\beta$, and $A\alpha : B\beta = b : a$, and, by similarity of triangles, $CA : CB = b : a$.

If a third body D, whose quantity of matter is d, be added, the common centre of position E of the three bodies is in the straight line DC, joining the centre D of the third body with the centre C of the other two, and $DE : EC = a + b : d$. For, passing the plane $\delta E \kappa$ through E, and drawing the perpendiculars $D\delta$, $C\kappa$, the sum of the perpendiculars from D is $d \times D\delta$; and the sum of the perpendiculars from A and B is $\overline{a+b} \times C\kappa$, and we have $d \times D\delta = \overline{a+b} \times C\kappa$; and therefore $DE : EC = a + b : d$.

In like manner, if a fourth body be added, the common centre is in the line joining the fourth with the centre of the other three, and its distance from this centre and from the fourth is inversely as the quantities of matter; and so on for any number of bodies.

If all the particles of any system be moving uniformly, in straight lines, in any directions, and with any velocities whatever, the centre of the system is either moving uniformly in a straight line, or [illegible].

For, let m be the number of particles in the system. Suppose any particle to move uniformly in any direction. It is evident from the reasoning in a former paragraph, that the motion of the common centre is the mth part of this motion, and is in the same direction. The same must be said of every particle. Therefore the motion of the centre is the motion which is compounded of the mth part of the motion of each particle. And because each of these was supposed to be uniform and rectilineal, the motion compounded of them all is also uniform and rectilineal; or it may happen that they will so compensate each other that there will be no diagonal, and the common centre will remain at rest.

Cor. 1. If the centres of any number of bodies move uniformly in straight lines, whatever may have been the motions of each particle of each body, by rotation or otherwise, the motion of the common centre will be uniform and rectilineal.

Cor. 2. The quantity of motion of such a system is the sum of the quantities of motion of each body, reduced to the direction of the centre's motion. And it is had by multiplying the quantity of matter in the system by the velocity of the centre.

The velocity of the centre is had by reducing the motion of each particle to the direction of the centre's motion, and then dividing the sum of those reduced motions by the quantity of matter in the system.

By the selection of this point, we render the investigation of the motions and actions of bodies incomparably more simple and easy, freeing our discussions from numberless intricate complications of motion, which would frequently make our progress almost impossible.

POSITION, in arithmetic, called also *False Position*, or *Supposition*, or *Rule of False*, is a rule so called, because it consists in calculating by false numbers supposed or taken at random, according to the process described in any question or problem proposed, as if they were the true numbers, and then from the results, compared with that given in the question, the true numbers are found.

Thus, take or assume any number at pleasure for the number sought, and proceed with it as if it were the true number, that is, perform the same operations with it as, in the question, are described to be performed with the number required: then if the result of those operations be the same with that mentioned or given in the question, the supposed number is the same as the true one that was required; but if it be not, make this proportion, *viz.* as your result is to that in the question, so is your supposed false number to the true one required.

Example. What number is that, to which if we add $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, and $\frac{1}{6}$ of itself, the sum will be 240?

Suppose 99

$$\begin{array}{rl} 49.5 & = \frac{1}{2} \\ 33. & = \frac{1}{3} \\ 24.75 & = \frac{1}{4} \\ 16.5 & = \frac{1}{6} \\ \hline 222.75 & = \text{result} \end{array}$$

Then, as $222.75 : 240 :: 99 : 106.6$ = Answer.

$$\begin{array}{rl} 53.\dot{3} & = \frac{1}{2} \\ 35.\dot{5} & = \frac{1}{3} \\ 26.\dot{6} & = \frac{1}{4} \\ 17.\dot{7} & = \frac{1}{6} \\ \hline 240. & = \text{proof.} \end{array}$$

This is *single* position.

Sometimes it is necessary to make two different suppositions or assumptions, when the same operations must be performed with each as in the single rule. If neither of the supposed numbers solve the question, find the differences between the results and the given number; multiply each of these differences into the other's position; and if the errors in both suppositions be of the same kind, *i. e.* if both suppositions be either less or greater than the given number, divide the differences of the products by the differences of the errors. If the errors be not of the same kind, *i. e.* if the one be greater and the other less than the given number, divide the sum of the products by the sum of the errors. The quotient, in either case, will be the answer.

Example. Three partners, A, B, and C, bought a sugar-work which cost them L. 2000; of which A paid a certain sum unknown; B paid as much as A, and L. 50 over; C paid as much as them both, and L. 75 over: What sum did each pay?

(1.) Suppose A paid L. 500

$$\begin{array}{rr} \text{B} \text{ ---- } & 550 \\ \text{C} \text{ ---- } & 1075 \\ \hline & 2125 \\ & 2000 \\ \hline & 125 = \text{error of excess.} \end{array}$$

(2.) Sup-

(2.) Suppose A paid L. 400
B —— 450
125 = excess. C —— 875

400 = 2d position. 1725
2000
50000
275 = error of defect.
500 = 1st position.

1st error, 125 137500
2d —— 275 50000

400)187500

Answers. { 468.75 = sum paid by A. / 518.75 = —— B. / 1012.5 = —— C. }

2000... = proof.

This is called double position.

POTTERY is an art of very considerable importance; and in addition to what has been said on it in the *Encyclopædia*, the following reflections, by that eminent chemist Vauquelin, will probably be acceptable to many of our readers.

Four things (says he) may occasion difference in the qualities of earthen-ware: *1st*, The nature or composition of the matter; *2d*, The mode of preparation; *3d*, The dimensions given to the vessels; *4th*, The baking to which they are subjected. By composition of the matter, the author understands the nature and proportions of the elements of which it is formed. These elements, in the greater part of earthen-ware, either valuable or common, are silex, argil, lime, and sometimes a little oxyd of iron. Hence it is evident that it is not so much by the diversity of the elements that good earthen-ware differs from bad, as by the proportion in which they are united. Silex or quartz makes always two-thirds at least of earthen-ware; argil or pure clay, from a fifth to a third; lime, from 5 to 20 parts in the hundred; and iron, from 0 to 12 or 15 parts in the hundred. Silex gives hardness, infusibility, and unalterability; argil makes the paste pliable, and renders it fit to be kneaded, moulded, and turned at pleasure. It possesses at the same time the property of being partially fused by the heat which unites its parts with those of the silex; but it must not be too abundant, as it would render the earthen-ware too fusible and too brittle to be used over the fire.

Hitherto it has not been proved by experience that lime is necessary in the composition of pottery: and if traces of it are constantly found in that substance, it is because it is always mixed with the other earths, from which the washings and other manipulations have not been able to separate it. When this earth, however, does not exceed five or six parts in a hundred, it appears that it is not hurtful to the quality of the pottery; but if more abundant, it renders it too fusible.

The oxyd of iron, besides the inconvenience of communicating a red or brown colour, according to the degree of baking, to the vessels in which it forms a part, has the property of rendering them fusible, and even in a greater degree than lime.

As some kinds of pottery are destined to melt very penetrating substances, such as salts, metallic oxyds, glass, &c. they require a fine kind of paste, which is obtained only by reducing the earths employed to very minute particles. Others destined for melting metals, and substances not very penetrating, and which must be able to support, without breaking, a sudden transition from great heat to great cold, require for their fabrication a mixture of calcined argil with raw argil. By these means you obtain pottery, the coarse paste of which resembles *breche*, or small-grained pudding-stone, and which can endure sudden changes of temperature.

The baking of pottery is also an object of great importance. The heat must be capable of expelling humidity, and agglutinating the parts which enter into the composition of the paste, but not strong enough to produce fusion; which, if too far advanced, gives to pottery a homogenuousness that renders it brittle. The same effect takes place in regard to the fine pottery, because the very minute division given to the earths reduces them nearly to the same state as if this matter had been fused. This is the reason why porcelain strongly baked is more or less brittle, and cannot easily endure alternations of temperature. Hence coarse porcelain, in the composition of which a certain quantity of calcined argil is employed, porcelain retorts, crucibles, tubes, and common pottery, the paste of which is coarse, are much less [illegible] formed of the same substances [illegible].

The general and [illegible] different parts of which of earthen-ware [illegible] their [illegible] to stand the fire.

In some cases the glazing or covering [illegible] when too thick, and of a nature different from [illegible] liable to break. [illegible] in [illegible] it is always [illegible] [illegible] the principles; 2d. To [illegible] the paste, by grinding [illegible] [illegible] which it is intend[illegible] [illegible] de[illegible] [illegible] fused [illegible] [illegible] of [illegible] possible to that of [illegible] may be more intimately [illegible]

C. Vauquelin being persuaded that the quality of good pottery depends chiefly on using proper proportions of the earthy matters, thought it might be of importance to those engaged in this branch of manufacture, to make known the analysis of different natural clays employed for this purpose, and of pottery produced by some of them, in order that, when a new earth is discovered, it may be known by a simple analysis whether it will be proper for the same object, and to what kind of pottery already known it bears the greatest resemblance.

	Hessian Crucibles.	Argil of Dieux.	Porcelain Capsules.	Wedgewood's Pyrometers.
Silex	69	43·5	61	64·2
Argil	21·5	33·2	28	25
Lime	1	3·5	6	6
Oxyd of iron	8	1	0·5	0·2
Water	. . .	18	. . .	6·2

Raw

Raw kaolin 100 parts.—Silex 74, argil 16·5, lime 2, water 7. A hundred parts of this earth gave eight of alum, after being treated with the sulphuric acid.

Washed kaolin 100 parts.—Silex 55, argil 27, lime 2, iron 0·5, water 14. This kaolin, treated with the sulphuric acid, gave about 45 or 50 *per cent.* of alum.

Petuntzé.—Silex 74, argil 14·5, lime 5·5, loss 6. A hundred parts of this substance, treated with the sulphuric acid, gave seven or eight parts of alum. But this quantity does not equal the loss sustained.

Porcelain of retorts.—Silex 64, argil 28·8, lime 4·55, iron 0·50, loss 2·77. Treated with the sulphuric acid, this porcelain gave no alum.

There is a kind of earthen vessels, called *Alcarrazes*, used in Spain for cooling the water intended to be drunk. These vessels consist of 60 parts of calcareous earth, mixed with alumina and a little oxyd of iron, and 36½ of siliceous earth, also mixed with alumina and the same oxyd. The quantity of iron may be estimated at almost one hundredth part of the whole. This earth is first kneaded into a tough paste, being for that purpose previously diluted with water; formed into a cake of about six inches in thickness, and left in that state till it begin to crack. It is then kneaded with the feet, the workman gradually adding to it a quantity of sea-salt, in the proportion of [illegible] pounds to a hundred and fifty; after which it is applied to the lath, and baked in any kind of furnace used by potters. The alcarrazes, however, are only about half as much baked as the better kinds of common earthen ware; and being exceedingly porous, water comes through their whole sides. Hence the air, which comes in contact with it, by making it evaporate, carries off the caloric contained in the water [illegible] rendered remarkably cool.

POULES, or Foulahs, [illegible] nations which inhabit the banks [illegible] They possess an extent of [illegible] river, and extend [illegible] ders with the interior of the country [illegible] so black as the other negroes, but [illegible] much inclining to red. [illegible] their children who are sent to Senegal [illegible] for some years, become much blacker [illegible] are very handsome, and the whites of Senegal [illegible] take care to procure some of them. But they are of a bad disposition, and utterly incapable of attachment. When a man has a mistress of this nation, he must watch her conduct very narrowly, and even chastise her, that she may not be guilty of infidelity to him whom she honours with her favours. The dread of the bastinado will, in such case, effect what attention and complaisance can never bring about.

Although the Poules inhabit one of the finest spots in Africa, they are nevertheless a wretched people; they are base, cruel, thievish, and fanatic in the extreme. They are commanded by a chief of their religion, which is a contemptible mixture of Mahometanism and idolatry. This chief is called the *Almamy;* he is always chosen from among the Tampsirs, who are twelve in number. The Tampsirs are the interpreters of the law, and are the most learned, or rather the most fanatical among them. The Almamy has the power of life and death over his subjects; yet he may be deposed by an assembly of Tampsirs: it is therefore his interest to keep on good terms with them. The payment of customs is made to the Almamy, and is afterwards distributed among the Tampsirs; and although a part belongs to the former, he nevertheless requires a separate present for himself.

Printing.

PRINTING. (See that article, *Encycl.* and TYPOGRAPHY in this *Supplement.*) We shall here only describe a *Printing-Press*, for the invention of which a patent was granted, in 1790, to Mr William Nicholson of New North-street, Red Lion Square, London. This machine, with some slight varieties, is adapted for printing on *paper, linen, cotton, woollen*, and other articles, in a more neat, cheap, and accurate method, the author thinks, than the printing presses now in use.

The invention consists in three particulars, *1st*, The manner of preparing and placing the types, engravings, or carvings, from which the impression is to be made; *2dly*, In applying the ink or colouring matter to types or engravings; and, *3dly*, In taking off the impression.

1st, Mr Nicholson makes his moulds, punches, and matrices, for casting letters, in the same manner, and with the same materials, as other letter-founders do, excepting that, instead of leaving a space in the mould for the stem of one letter only, he leaves spaces for two, three, or more letters, to be cast at one pouring of the metal; and at the lower extremity of each of those spaces (which communicate by a common groove at top) he places a matrix, or piece of copper, with the letter punched upon its face in the usual way. And moreover, he brings the stem of his letters to a due form and finish, not only by rubbing it upon a stone, and scraping it when arranged in the finishing-stick, but likewise by scraping it, on one or more sides, in a finishing-stick whose hollowed part is less deep at the inner than the outer side. He calls that side of the groove which is nearest the face of the disposed letter, the outer side; and the purpose accomplished by this method of scraping is, that of rendering the tail of the letter gradually smaller the more remote it is, or farther from the face. Such letters may be firmly imposed upon a cylindrical surface, in the same manner as common letters are imposed upon a flat stone.

2dly, He applies the ink or colouring matter to the types, forms, or plates, by causing the surface of a cylinder, smeared or wetted with the colouring matter, to roll over the surfaces of the said forms or plates, or by causing the forms or plates apply themselves successively to the surface of the cylinder. The surface of this colouring cylinder is covered with leather, or with woollen, linen, or cotton-cloth. When the colour to be used is thin, as in calico-printing, and in almost every case, the covering is supported by a firm elastic stuffing, consisting of hair, or wool, or woollen cloth wrapped one or more folds round the cylinder. When the covering consists of woollen cloth, the stuffing must be defended by leather, or oilskin, to prevent its imbibing too much colour, and by that means losing its elasticity. It is absolutely necessary that the colouring matter be evenly distributed over the surface of the cylinder; and for this purpose, when the colour is thick and stiff, as in letter-press printing, he applies two, three, or more small cylinders, called distributing-rollers, longitudinally against the colouring cylinders, so that they may be turned by the motion of the latter; and the effect of this application is, that every lump or mass of colour which may be redundant, or irregularly placed upon the face of the colouring cylinder, will be pressed, spread,

Printing.

spread, and partly taken up, and carried by the small rollers to the other parts of the colouring cylinder; so that this last will very speedily acquire and preserve an even face of colour. But if the colouring matter be thinner, he does not apply more than one or two of these distributing rollers; and, if it be very thin, he applies an even blunt edge of metal, or wood, or a straight brush, or both of these last, against the colouring cylinder, for the purpose of rendering its colour uniform. When he applies colour to an engraved plate, or cylinder, or through the interstices of a perforated pattern, as in the manufacturing of some kinds of paper-hangings, he uses a cylinder entirely covered with hair or bristles in the manner of a brush.

3dly, He performs all his impressions, even in letter-press printing, by the action of a cylinder or cylindrical surface. The construction of this machine, and the manner of using it, will be intelligible to every reader, who shall attentively consider Plate XL; where fig. 1. represents a printing press, more especially applicable to the printing of books. A and E are two cylinders, running or turning in a strong frame of wood, or metal, or both. The cylinder A is faced with woollen cloth, and is capable of being pressed with more or less force upon HI, by means of the lever M. HI is a long table, which is capable of moving endwise, backwards and forwards, upon the rollers E and K. The roller A acts upon this table by means of a cog-wheel, or by straps, so as to draw it backwards and forwards by the motion of its handle L. The table is kept in the same line by grooves on its sides, which contain the cylinder A. D is a chase, containing letter set up and imposed. B is a box, containing a colouring-roller, with its distributing rollers CC; it is supported by the arm N. O is a cylinder faced with leather, and lying across an ink-block; this cylinder is fixed by the middle to a bended lever moveable on the joint Q.

The action. When D, or the letter, is drawn beneath the cylinder B, it receives ink; and when it has passed into the position R, a workman places or turns down a tympan with paper upon it (this tympan differs in no respect from the usual one, except that its hinge opens sidewise); it then proceeds to pass under the cylinder A, which presses it successively through its whole surface. On the other side, at S, the workman takes off the paper, and leaves the tympan up. This motion causes the cylinder B to revolve continually, and consequently renders its inked surface very uniform, by the action of its distributing-rollers CC; and, when the table has passed to its extreme distance in the direction now spoken of, the arm G touches the lever P, and raises the cylinder O off the ink-block, by which means it dabs against one of the distributing-rollers, and gives it a small quantity of ink. The returning motion of the table carries the letter again under the roller B, which again inks it, and the process of printing another sheet goes on as before.

Fig. 2. is another printing-press. In this, B is the inking-roller; A is a cylinder, having the letter imposed upon its surface; and E is a cylinder, having its uniform surface covered with woollen cloth: these three cylinders are connected, either by cogs or straps at the edges of each. The machine is uniformly turned in one direction by the handle L. The workman applies a sheet of paper to the surface of E, where it is retained, either by points in the usual manner, or by the apparatus to be described in treating of fig. 4. The paper passes between E and A, and receives an impression; after which the workman takes it off, and applies another sheet; and in the mean time the letter on the surface of A passes round against the surface of B, and receives ink during the rotation of B. The distributing-rollers CC do their office as in the machine fig. 1.; and once in every revolution the tail F, affixed to B, raises the inking-piece G, so as to cause it to touch one of the distributing-rollers, and supply it with ink. In this way therefore the repeated printing of sheet after sheet goes on.

Fig. 3. is a printing press, more particularly adapted to print cottons, silks, paper hangings, or other articles which run of a considerable length. A is a cylinder covered with woollen cloth, or other soft substance. The web or piece of cotton, or other goods, is passed round this cylinder, from the carrying-roller F to the receiving-rollers GH; which are connected by a piece of linen, woollen, or hair-cloth, in the manner of a jack-towel sewed round them; the rotation of this towel carries away the printed stuff or goods, and deposits them at I. KL is a moveable box, containing three rollers, which move against each other in rotation. The lowest roller C revolves in a mass of colour, contained in a trough or vessel in the bottom part of the box KL; the [illegible] of this colour is represented by the line [illegible]. The [illegible] roller B is stuffed and covered as described in [illegible] 2. The pressure of B against C prevents the cylinder B from receiving too much colour. D is a cut or carved cylinder, which receives colour, during the rotation, from the roller B, and imprints it upon the web as it [illegible] round the cylinder A. In this way the construction [illegible] [illegible] is sufficiently obvious. [illegible] cylinders ADB and G [illegible] wheels, straps, or other well-known [illegible]; so that the handle [illegible] depending on [illegible]. The pressure [illegible] adjustment of [illegible] A is governed by [illegible] KL. When it is required [illegible] colour upon a piece, Mr [illegible] it to pass two or more times through the machine; or, in those cases where the materials are liable to change their dimensions, he applies, at one and the same time, two or more such boxes as KL, with their respective cylinders, so that the pattern cylinder of each may make its impression upon the web or material to be printed on.

Fig. 4. is a printing-press, chiefly of use for books and papers. 1, 2, 3, 4, represents a long table, with ledges on each side; so that the two cylinders A and B can run backwards and forwards without any side shake. In one of these ledges is placed a strip or plate of metal cut into teeth, which lock into correspondent teeth in each cylinder; by which means the two cylinders roll along, without the possibility of changing the relative positions of their surfaces at any determinate part of the table. This may also be effected by straps, and may indeed be accomplished, with tolerable accuracy, by the mere rolling of the cylinders on the smooth or flat ledges without any provision. A is the printing-cylinder, covered with woollen cloth, and B is the inking-cylinder, with its distributing rollers. The tab[le]

may be divided into four compartments, marked with a thicker bounding line than the rest, and numbered 1, 2, 3, 4. At 1 is placed a sheet of paper; at 2 is the form or chase, containing letter set and imposed; at 3 is an apparatus for receiving the printed sheet; and 4 is employed in no other use than as a place of standing for the carriage E, after it has passed through one operation, and when it takes ink at F. Its action is as follows: the carriage is thrust forward by the workman, and as the roller A passes over the space numbered 1, it takes up the sheet of paper previously laid there, while the roller B runs over the form and inks the letter. The sheet of paper, being wrapped round the cylinder A, is pressed against the form as that cylinder proceeds, and consequently it receives an impression. When A arrives at the space numbered 3, it lets go the sheet of paper, while the prominent part of the carriage G strikes the lever P, and raises the inking-piece, which applies itself against one of the distributing-rollers. In this manner therefore the cylinder A returns empty, and the cylinder B inked, and in the mean time the workman places another sheet of paper ready in the space numbered 1. Thus it is that the operation proceeds in the printing of one sheet after another.

The preceding description is not incumbered with an account of the apparatus by which the paper is taken up and laid down. This may be done in several ways: Fig. 9. and 10. represent one of the methods. DE is a lever, moving on the centre pin C, and having its end D pressed upwards by the action of the spring G. The shoulder which contains the pin C is fixed in another piece F, which is inserted in a groove in the surface of the cylinder A (fig. 9.), so that it is capable of moving in and out [illegible] to the axis of that cylinder. [illegible] cylinder proceeds, it meets a pin in the table, which [illegible] (fig. 9.) acting on the inclined plane at the other end of the lever, throws the whole inwards [illegible] in fig. 10.; in which case the [illegible] wards, and applies itself against the [illegible].

In fig. 11. is a representation of [illegible]; the dotted square represents a sheet [illegible] the four small shaded squares denote [illegible] with pins standing beside them. When the lever DE (fig. 10.) shoots forward, it is situated in one of these holes, and advances under the edge of the paper, which consequently it presses and retains against the cylinder with its extremity D. Nothing more remains to be said respecting the taking up, but that the cylinder is provided with two pair of these clasps or levers, which are so fixed as to correspond with the four holes represented in fig. 11. It will be easy to understand how the paper is deposited in the compartment n° 3. (fig. 4.) A pin P (fig. 10.) rising out of the platform or table, acts against a pin E, projecting sidewise out of the lever, and must of course draw the slider and its lever to the original position; the paper consequently will be let go, and its disengagement is rendered certain by an apparatus fixed in the compartment numbered 3. (fig. 4.) of exactly the same kind as that upon the cylinder, and which, by the action of a pin duly placed in the surface of the cylinder A, takes the paper from the cylinder in precisely the same manner as that cylinder originally took it up in the compartment numbered 1 (fig. 4.)

Figs. 5, 6, and 7, represent a simpler apparatus for accomplishing the same purpose. If A a B b (fig 7.) be supposed to represent a thick plate of metal of a circular form, with two pins, A and B, proceeding sidewise or perpendicularly out of its plane, and diametrically opposite to each other, and G another pin proceeding in the direction of that plane, then it is obvious that any force applied to the pin A, so as to press it into the position *a* (by turning the plate on its axis or centre X), will at the same time cause the pin G to acquire the position *g*; and, on the other hand, when B is at *b*, or the dotted representation of the side pin, if any pressure be applied to restore its original position at B, the pin *g* will return back to G. Now the figures 5 and 6 exhibit an apparatus of this kind, applied to the cylinder A; and that cylinder, by rolling over the pins P and *p*, properly fixed in the table to re act upon the apparatus, will cause its prominent part G either to apply to the cylinder and clasp the paper, or to rise up and let it go. The compartment numbered 3 (fig. 4.) must of course have an apparatus of the same kind to be acted upon by pins from A, in order that it may take the paper from that cylinder.

There is one other circumstance belonging to this machine which remains to be explained. When the carriage E (fig. 4.) goes out in the direction of the numbers 1, 2, 3, 4, both rollers, A and B, press the form of letter in their passage; but in their return back again the roller A, having no paper upon it, would itself become soiled, by taking a faint impression from the letter, if it were not prevented from touching it; the manner of effecting this may be understood from fig. 12. The apparatus there represented is fixed upon the outside of the carriage E, near the lower corner, in the vicinity of the roller A; the whole of this projects sidewise beyond the ledge of the table, except the small truck or wheel B. The irregularly triangular piece, which is shaded by the stroke of the pen, carries this wheel, and also a catch moveable on the axis or pin E. The whole piece is moveable on the pin A, which connects it to the carriage. CD, or the part which is shaded by dotting, is a detent, which serves to hold the piece down in a certain position. It may be observed, that both the detent and the triangular piece are furnished each with a claw, which holds in one direction, but trips or yields in the other, like the jacks of a harpsichord, or resembling certain pieces used in clock and watch making, as is clearly represented in the figure. These claws overhang the side of the table, and their effect is as follows: There is a pin C (fig. 4.) between the compartments of the table numbered 2 and 3, but which is marked F in fig. 12. where GH represents the table. In the outward run of the carriage these claws strike that pin, but with no other effect than that they yield for an instant, and as instantly resume their original position by the action of their respective slender back-springs. When the carriage returns, the claw of the detent indeed strikes the pin, but with as little effect as before, because its derangement is instantly removed by the action of the back spring of the detent itself; but, when the claw of the triangular piece takes the pin, the whole piece is made to revolve on its axis or pin A, the wheel B is forced down, so as to lift that end of the carriage, and the detent, catching on the piece at C, prevents the former position from being recovered.

covered. The consequence of this is, that the carriage runs upon the truck B (and its correspondent truck on the opposite side) instead of the cylinder A, which is too much raised to take the letter, and soil itself; but as soon as the end of the carriage has passed clear of the letter, another pin R (fig. 4.) takes the claw of the detent, and draws it off the triangular piece; at which instant the cylinder A subsides to its usual place, and performs its functions as before. This last pin R does not affect the claw of the triangular piece, because it is placed too low; and the claw of the detent is made the longest, on purpose that it may strike this pin.

Fig. 8. represents an instrument for printing floor-cloths, paper-hangings, and the like, with stiff paint and a brush. D is a copper or metallic cylinder fixed in a frame A, like a garden roller; its carved part is thin, and is cut through in various places, according to the desired pattern. A strong axis passes through the cylinder, and its extremities are firmly attached to the frame A. To this axis is fixed a vessel or box of the same kind, and answering the same purpose as the box KL in fig. 3. It carries a cylinder P, which revolves in the colour; another cylinder E, which revolves in contact with P; and a third cylinder B, whose exterior surface is covered with hair, after the manner of a brush, and revolves in contact with E. This cylinder B is adjusted by its axis, in such a manner that its brush-part sweeps in the perforated parts of the metallic cylinder D. The circle C represents a cog-wheel, fixed concentric to the cylinder D, and revolving with it; this wheel takes another wheel concentric to, and fixed to, B; hence the action is as follows: When the metallic cylinder is wheeled or rolled along any surface, its cog-wheel C drives the brush B in the contrary direction; and this brush-cylinder, being connected by cogs or otherwise with E and P, causes those also to revolve and supply it with colour. As the successive openings of the cylinder D, therefore, come in contact with the ground, the several parts of the brush will traverse the uncovered part of that ground, and paint the pattern upon it. The wheel G, being kept lightly on the ground, serves to determine the line of contact, that it shall be the part opposite to B, and no other.

PRINTS (see *Encycl.*) are valuable on many accounts; but they are liable to be soiled by smoke, vapour, and the excrements of insects. Different methods have, of course, been practised to clean them. Some have proposed simple washing with clear water, or a ley made of the ashes of reeds, and then exposing the prints to the dew. Others have cleaned prints with *aqua fortis* (sulphuric acid); but both these methods are attended with a degree of risk at least equal to their advantages. The following method of cleaning prints is recommended in the second volume of Nicholson's Journal of Natural Philosophy, &c. as at once safe and efficacious:

"Provide a certain quantity of the common muriatic acid, for example three ounces, in a glass bottle, with a ground-stopper, of such a capacity that it may be only half full. Half an ounce of minium must then be added; immediately after which the stopper is to be put in, and the bottle set in a cold and dark place. The heat, which soon becomes perceptible, shews the beginning of the new combination. The minium abandons the greatest part of its oxygen with which the fluid remains impregnated, at the same time that it acquires a fine golden yellow, and emits the detestable smell of oxygenated muriatic acid. It contains a small portion of muriat of lead; but this is not at all noxious in the subsequent process. It is also necessary to be observed, that the bottle must be strong, and the stopper not too firmly fixed, otherwise the active elastic vapour might burst it. The method of using this prepared acid is as follows:

"Provide a sufficiently large plate of glass, upon which one or more prints may be separately spread out. Near the edges let there be raised a border of soft white wax half an inch high, adhering well to the glass and flat at top. In this kind of trough the print is to be placed in a bath of fresh urine, or water containing a small quantity of ox-gall, and kept in this situation for three or four hours. The fluid is then to be decanted off, and pure warm water poured on, which must be changed every three or four hours until it passes limpid and clear. The impurities are sometimes of a resinous nature, and resist the action of pure water. When this is the case, the washed print must be left to dry, and alcohol is then to be poured on and left for a time. After the print is thus cleaned, and all the moisture drained off, the muriatic acid prepared with minium is to be poured on in sufficient quantity to cover the print; immediately after which another plate of glass is to be laid in contact with the rim of wax, in order to prevent the inconvenient exhalation of the oxygenated acid. In this situation the yellowest print will be seen to recover its original whiteness in a very short time. One or two hours are sufficient to produce the desired effect; but the print will receive no injury if it be left in [illegible] for a whole night. Nothing more is necessary to complete the work than to decant off the remaining acid, and wash away every trace of acidity by repeated affusions of pure water. The print being then left to dry (in the sun if possible) will be found white, clean [illegible], and in no respect damaged either in the texture of the paper or the tone and appearance of the impression.

"The [illegible] editor of the Journal subjoins the following note, to which collectors of prints will do well to pay attention: "As I have not repeated this process, I cannot estimate how far the presence of the lead may weaken the corrosive action of the acid on the paper, but I should be disposed to recommend a previous dilution of the acid with water. Whoever uses this process will of course make himself master of the proportion of water required to dilute the acid, by making his first trials with an old print of no value.""

PRISM, in geometry, is a body or a solid, whose two ends are any plane figures which are parallel, equal, and similar; and its sides, connecting those ends, are parallelograms. The definition of this figure in the *Encyclopædia* we must, in candour, acknowledge to be unaccountably indistinct, if not unintelligible.

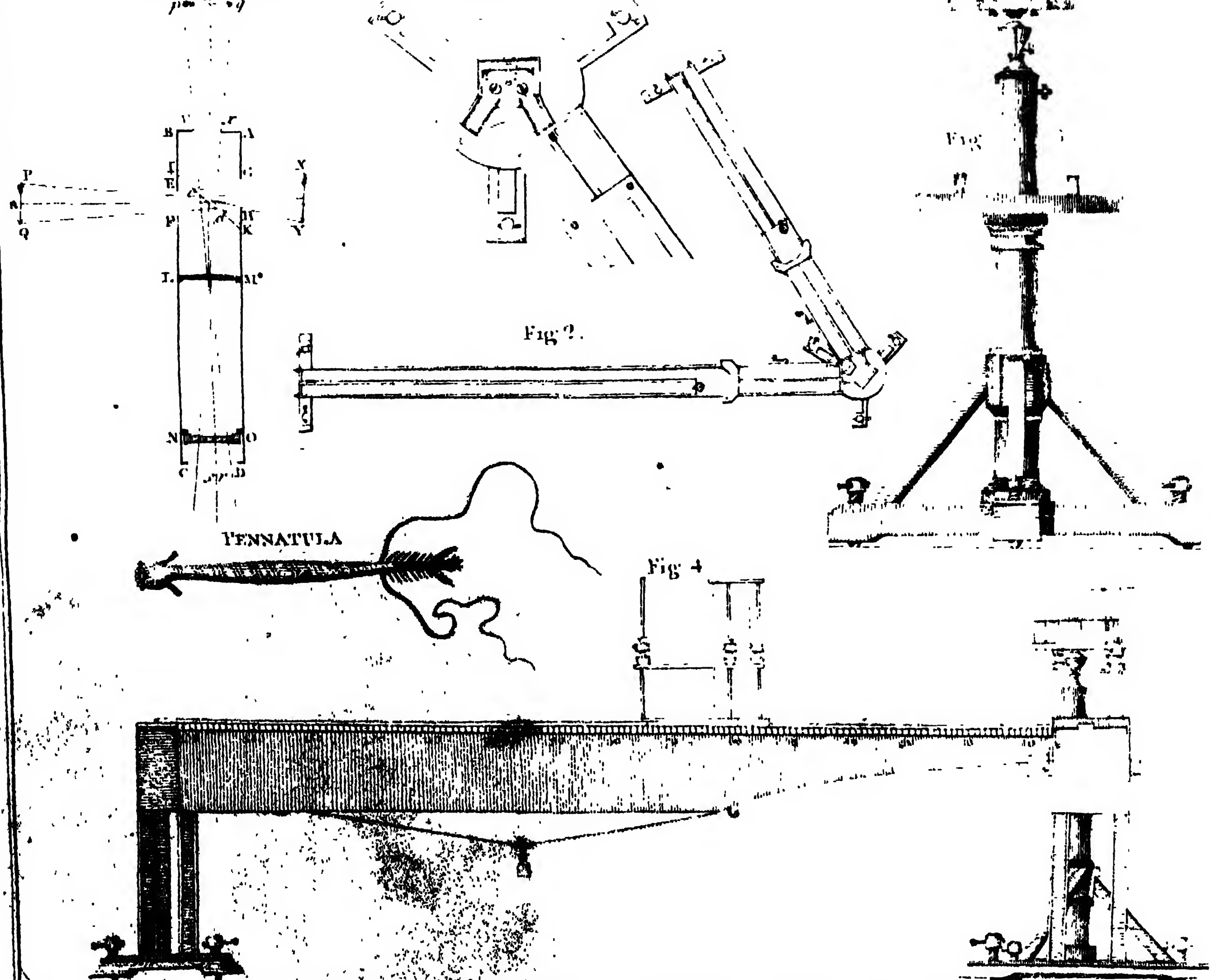
PRISMOID, is a solid or body, somewhat resembling a prism, but that its ends are any dissimilar parallel plane figures of the same number of sides; the upright sides being trapezoids.—If the ends of the prismoid be bounded by dissimilar curves, it is sometimes called a *cylindroid*.

PRISON is said, in the *Encyclopædia*, to be only a place of safe custody, not a place of punishment. Such was

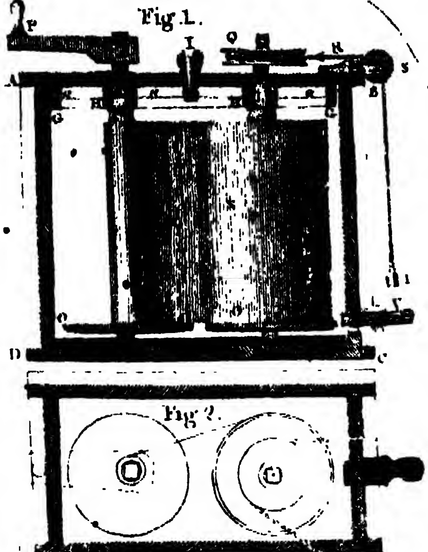
OPERA GLASS.

Photometer Fig. 1, Fig. 2, Fig. 3, Fig. 4

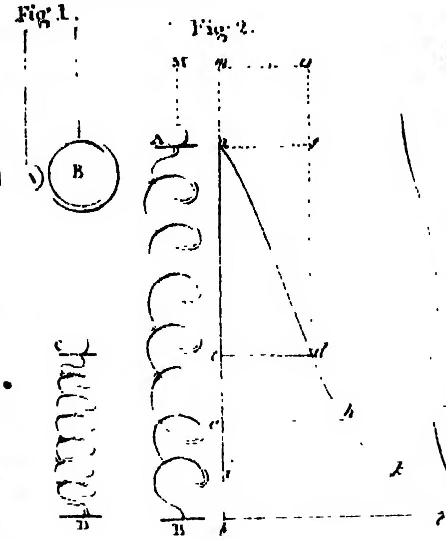
PENNATULA



BLEACHING Fig. 1. Fig. 2.

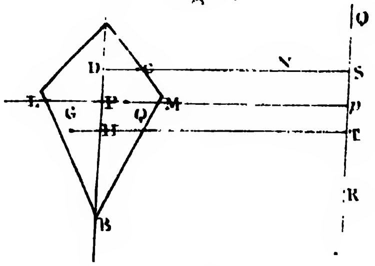


PERCUSSION Fig. 1. Fig. 2.



ORICOU

Fig: 1.



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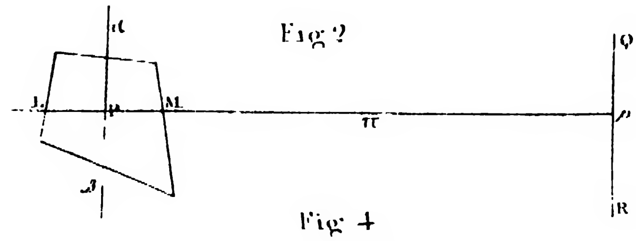

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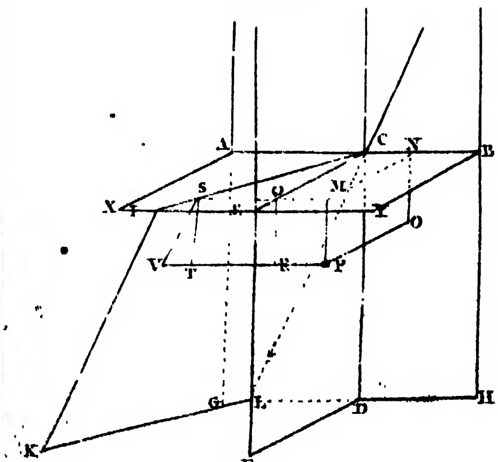

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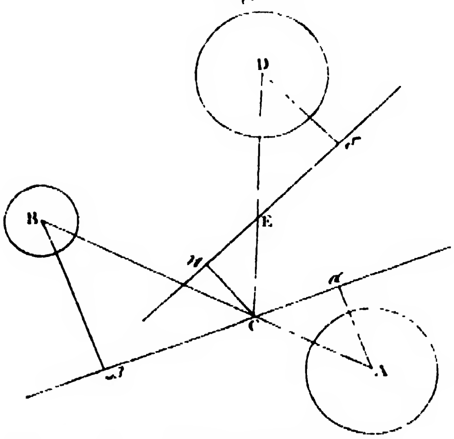

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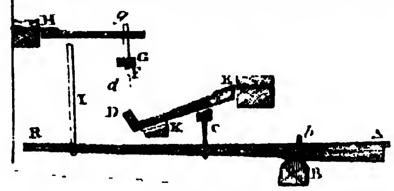

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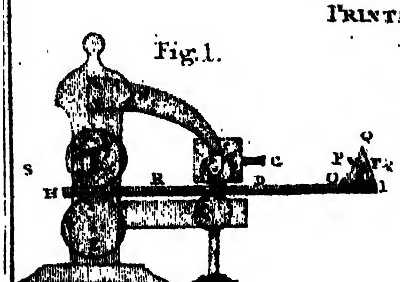

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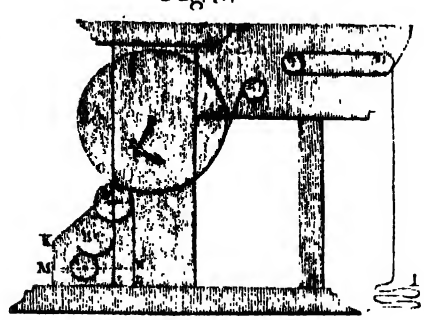

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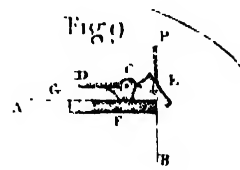

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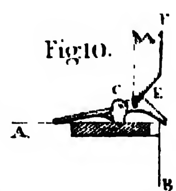
Fig.10.



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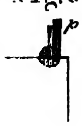

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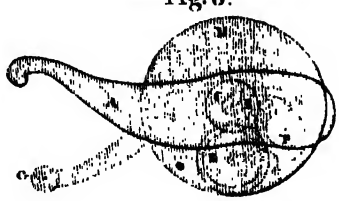

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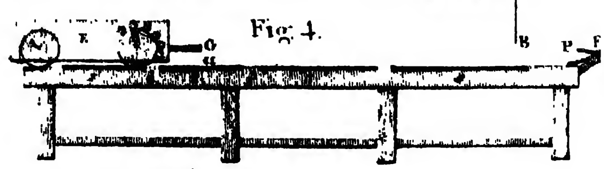

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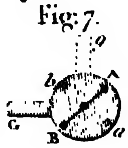

Fig.11.

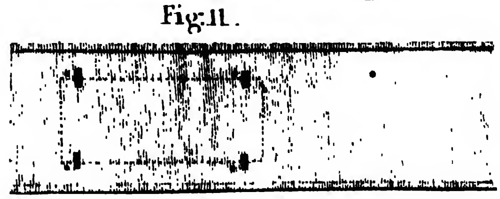

Fig.12.

Prison. was, no doubt, the original intention of English prisons; but now temporary confinement is, in England as well as elsewhere, inflicted as a punishment for certain crimes. Perhaps it would be expedient to substitute this punishment more frequently than is yet done in Great Britain, for transportation and death; proportioning the length of the confinement, as well as its closeness, to the heinousness of the crime. In no country, we believe, is this more accurately done, or to better purpose, than in Pennsylvania; and surely in no country has imprisonment been more abused than in Venice under the old government.

By the laws of Pennsylvania, punishment by imprisonment is imposed, not only as an expiation of past offences, and an example to the guilty part of society, but also for another important purpose—the reformation of the criminal's morals. The regulations of the gaol are calculated to promote this effect as soon as possible; so that the building deserves the name of a *penitentiary house* more than that of a *gaol* (see PHILADELPHIA, *Encycl.*) As soon as a criminal is committed to the prison, he is made to wash; his hair is shorn; and, if not decently clothed, he is furnished with clean apparel. He is then thrown into a solitary cell, about nine feet long and four wide, where he remains debarred from the sight of every living being except his gaoler, whose duty is to attend to his bare necessities, but who is forbidden on any account to hold conversation with him. If a prisoner be at all refractory, or if the offence for which he is committed be of a very atrocious nature, he is then confined to a cell secluded even from the light of heaven. The treatment of each prisoner, during his confinement, is varied according to his crime and his subsequent repentance. Solitary confinement in a dark cell is looked upon as the severest usage; next, solitary confinement in a cell with the admission of light; next, solitary confinement in a cell, where the prisoner is allowed to do some sort of work; and, lastly, labour in company with others. The longest period of confinement is for a rape, which is not to [illegible] in ten years, nor more than twenty-one; for treason, it is not to exceed twelve, nor fall short of six years.

The prisoners are obliged to bathe twice every week, proper conveniences for that purpose being provided within the walls of the prison, and also to change their linen, with which they are regularly supplied. Those in solitary confinement are kept upon bread and water; but those who labour are allowed broth, porridge, puddings, and the like. Meat is dispensed only in small quantities, twice in the week; and on no pretence whatever is any other beverage than water suffered to be brought into the prison. Those who labour are employed in the trade to which they have been accustomed; and for those acquainted with no particular trade, some kind of work is devised which they can perform. One room is set apart for shoemakers, another for tailors, a third for carpenters, and so on. In the yards are stone cutters, smiths, nailers, &c. In a word, this prison has all the advantages of the rasping house of Amsterdam, without any of its enormous defects. See *Correction-House* in this *Suppl.*

The prison of Venice is of a very different description, and is worthy of notice here only as a curiosity in the annals of tyranny, which has, we hope, passed away with the government which contrived it. Dr Moseley, in consequence of his being an English physician (a character then highly respected in Venice), was permitted, on the 16th of September 1787, to visit the common prison, but was absolutely refused admittance into the *Sotto Piombi*, where the state prisoners were kept. As the Doctor believes that no foreigner besides himself ever witnessed the scenes, even in the common prison, which he relates, we shall give his relation in his own words. Prison.

"I was conducted (says he) through the prison by one of its inferior dependants. We had a torch with us. We crept along narrow passages as dark as pitch. In some of them two people could scarcely pass each other. The cells are made of massy marble; the architecture of the celebrated Sansovini.

"The cells are not only dark, and black as ink, but being surrounded and confined with huge walls, the smallest breath of air can scarcely find circulation in them. They are about nine feet square on the floor, arched at the top, and between six and seven feet high in the highest part. There is to each cell a round hole of eight inches diameter, through which the prisoner's daily allowance of twelve ounces of bread and a pot of water is delivered. There is a small iron door to the cell. The furniture of the cell is a little straw and a small tub; nothing else. The straw is renewed and the tub emptied through the iron door occasionally.

"The diet is ingeniously contrived for the perduration of punishment. Animal food, or a cordial nutritious regimen, in such a situation, would bring on disease, and defeat the end of this Venetian justice. Neither can the soul, if so inclined, steal away, wrapt up in slumbering delusion, or sink to rest; from the admonition of her sad existence, by the gaoler's daily return.

"I saw one man who had been in a cell thirty years; two who had been twelve years; and several who had been eight and nine years in their respective cells.

"By my taper's light I could discover the prisoners horrid countenances. They were all naked. The man who had been there thirty years, in face and body was covered with long hair. He had lost the arrangement of words and order of language. When I spoke to him, he made an unintelligible noise, and expressed fear and surprise; and, like some wild animals in desarts, which have suffered by the treachery of the human race, or have an instinctive abhorrence of it, he would have fled like lightning from me if he could.

"One whose faculties were not so obliterated; who still recollected the difference between day and night; whose eyes and ears, though long closed with a silent blank, still languished to perform their natural functions—implored, in the most piercing manner, that I would prevail on the gaoler to murder him, or to give him some instrument to destroy himself. I told him I had no power to serve him in this request. He then entreated I would use my endeavours with the inquisitors to get him hanged, or drowned in the Canal' Orfano. But even in this I could not serve him: death was a favour I had not interest enough to procure for him.

"This kindness of death, however, was, during my

ley in Venice, granted to one man, who had been 'from the cheerful ways of man cut off' thirteen years.

"Before he left his dungeon I had some conversation with him; this was six days previous to his execution. His transport at the prospect of death was surprising. He longed for the happy moment. No saint ever exhibited more fervour in anticipating the joys of a future state, than this man did at the thoughts of being released from life, during the four days mockery of his trial.

"It is in the Canal' Orfano where vessels from Turkey and the Levant perform quarantine. This place is the watery grave of many who have committed political or personal offences against the state or senate, and of many who have committed no offences at all. They are carried out of the city in the middle of the night, tied up in a sack with a large stone fastened to it, and thrown into the water. Fishermen are prohibited, on forfeiture of their lives, against fishing in this district. The pretence is the plague. This is the secret history of people being lost in Venice.

"The government, with age, grew feeble; was afraid of the discussion of legal process and of public executions; and navigated this rotten Bucentaur of the Adriatic by spies, prisons, assassination, and the Canal' Orfano.'

This is indeed a frightful narrative, and, we doubt not, true as well as frightful; but when, from the state of the Venetian prisons, the author insinuates, that Howard was not actuated by genuine benevolence, and infers, or wishes his reader to infer, that the proposal of that celebrated philanthropist for substituting solitary confinement, in many cases, for capital punishment, must have resulted from his not taking into consideration the *mind* of the criminal—the insinuation, to say the least of it, is ungenerous, and the conclusion is at war with the premises. That there was something romantic and superfluous in Howard's wanderings, we readily admit; but it seems impossible to doubt of the reality of his benevolence; and though the horrid prison of Venice, into which, as the Doctor assures us, Mr Howard never entered, was calculated to injure the body without improving the mind of the criminal, it does not follow but that solitary confinement, under such regulations as at Philadelphia, is the best means that have yet been thought of for obtaining the object nearest Howard's heart, the reformation of the morals of the criminal.

PROCYON, in astronomy, a fixed star of the second magnitude, in Canis Minor, or the Little Dog.

PROSTHAPHERESIS, in astronomy, the difference between the true and mean motion, or between the true and mean place, of a planet, or between the true and equated anomaly; called also *equation of the orbit*, or *equation of the centre*, or simply the *equation*; and it is equal to the angle formed at the planet, and subtended by the eccentricity of its orbit.

PROTRACTING, or PROTRACTION, in surveying, the act of plotting or laying down the dimensions taken in the field, by means of a protractor, &c. Protracting makes one part of surveying.

Protracting-Pin, a fine pointed pin or needle, fitted into a handle, used to prick off degrees and minutes from the limb of the protractor.

PRUNING. Under this title (*Encycl.*) it is observed, that when large branches of trees bearing stone-fruit are taken off, the trees are subject to gum and decay. For this a remedy has been invented by *Thomas Skip Dyot Bucknall*, Esq; of Conduit street, which, notwithstanding many objections made to it at first, experience has proved to be successful, and for the discovery of which the Society for the Encouragement of Arts, &c. voted the silver medal to the discoverer. It is as follows:

Cut every branch which should be taken away close to the place of its separation from the trunk; smooth it well with a knife; and then with a painter's brush smear the wound over with what Mr Bucknall calls *medicated tar*. This medicated tar is composed of one quarter of an ounce of corrosive sublimate, reduced to fine powder by beating with a wooden hammer, and then put into a three-pint earthen pipkin, with about a glass full of gin or other spirit, stirred well together, and the sublimate thus dissolved. The pipkin is then filled by degrees with vegetable or common tar, and constantly stirred, till the mixture be blended together as intimately as possible; and this quantity will at any time be sufficient for two hundred trees. To prevent danger, let the corrosive sublimate be mixed with the tar as quickly as possible after it is purchased; for, being of a very poisonous nature to all animals, it should not be suffered to lie about a house, for fear of mischief to some part of the family.

By the application of this composition, Mr Bucknall can, without the smallest danger, use the pruning hook on all kinds of trees much more freely than we have recommended its use in the article referred to. "I give no attention (says he) to fruit-branches, and wood-branches; but beg, once for all, that no branch shall ever be shortened, unless for the figure of the tree, and then constantly taken off close to the separation, by which means the wound soon heals. The more the range of the branches shoots circularly, a little inclining upwards, the more equally will the sap be distributed, and the better will the tree bear; for, from that circumstance, the sap is more evenly impelled to every part. Do not let the ranges of branches be too near each other; for remember all the fruit and the leaves should have their full share of the sun; and where it suits let the middle of the tree be free from wood, so that no branch shall ever cross another, but all the extreme ends point outwards."

PULO, the name of several islands of Asia, in the Indian Ocean; the principal of which alone, according to Dr Brooke's, is inhabited. This is the island

Pulo-Condore, which, being visited by Lord Macartney as he sailed to China, is thus described by Sir George Staunton. "It has the advantage of convenient anchoring places in either monsoon. The squadron accordingly stopped on the 17th of May, in a spacious bay on the eastern side of the island; and came to anchor at the entrance of its southern extremity, as the water shoaled there to five fathoms and a half, occasioned by a bank which stretches across two-thirds of the entrance. It was found afterwards, that beyond the bank there is a safe passage to the inner part of the bay, the north of which is sheltered by a small island lying to the eastward. The whole of the bay is formed by four small islands, which approach so nearly to each other, as to appear, from several points, to join.

2 They

They all seem to be the rude fragments of primitive mountains, separated from the great continent in the lapse of time. The principal island is eleven or twelve miles in length, and about three in breadth. It is in the form of a crescent, and consists of a ridge of peaked hills. Its latitude, as calculated from a meridional observation, is 8° 40′ north from the equator; and its longitude, according to a good chronometer, is 105° 55′ east from Greenwich.

"The English had a settlement on Condore until the beginning of the present century, when some Malay soldiers in their pay, in resentment for some unjustifiable treatment, murdered their superiors, with the exception of a very few who escaped off the island, where no Europeans have since resided. At the bottom of the bay was a village situated close to a fine sandy beach, with a long range of cocoa-nut trees before it, and it was defended from the north-east sea by a reef of coral rocks, within which was good anchorage for small vessels, and an easy landing for boats. A party went on shore from Lord Macartney's squadron, with the precaution, however, of being armed, as large canoes were espied within the reef, which might have been Malay pirates. Several of the inhabitants came to the beach, and with the appearance of much urbanity of manners welcomed them on shore, and conducted them to the house of their chief. It was a neat bamboo cabin, larger than the rest. The floor was elevated a few feet above the ground, and strewed with mats, on which were assembled as many men as the place could hold. It was apparently on the occasion of some festival, or pleasurable meeting. There was in one of the apartments an altar decorated with images, and the partitions hung with figures of monstrous deities; but the countenances and deportment of the people conveyed no idea of religious awe, and no person was seen in the posture of prayer or adoration. A few spears stood against the wall with their points downwards, together with some matchlocks and a swivel gun. The dress of these people was composed chiefly of blue cotton worn loosely about them; and their flat faces and little eyes denoted a Chinese origin or relation. Several long slips of paper, hanging from the ceiling, were covered with columns of Chinese writing. One of the missionaries, who was of the party, could not, however, in any degree, understand their conversation; but when the words were written, they instantly became intelligible to him. Though their colloquial language was altogether different from what is spoken in China, yet the characters were all Chinese; and the fact was clearly ascertained on this occasion, that those characters have an equal advantage with Arabic numbers, of which the figures convey the same meaning wherever known; whereas the letters of other languages denote not things, but elementary sounds, which combined variously together, form words, or more complicated sounds, conveying different ideas in different languages, though the form of their alphabet be the same.

"The inhabitants of Pulo Condore were, it seems, Cochin-Chinese, with their descendants, who fled from their own country, in consequence of their attachment to one of its sovereigns, dethroned by several of his own subjects. It was proposed to purchase provisions here; and the people promised to have the specified quantity ready, if possible, the next day, when it was intended, if the weather should be favourable, to land the invalids. The next morning was fair in the beginning; and a party of pleasure was made from the Hindostan to a small island close to Pulo Condore. They were scarcely arrived upon it when the weather began to lower; and the boat set off on its return, in order to reach the ship before the impending storm should begin.

"With difficulty it reached the ship; and as soon as the weather became fair, messengers were dispatched on shore to receive and pay for the provisions promised. When they arrived at the village, they were astonished to find it abandoned. The houses were left open, and none of the effects, except some arms, that had on the first visit been perceived within them, or even of the poultry feeding about the doors, were taken away. In the principal cabin a paper was found, in the Chinese language, of which the literal translation purported, as nearly as it could be made, that 'the people of the island were few in number, and very poor, yet honest, and incapable of doing mischief; but felt much terror at the arrival of such great ships and powerful persons, especially as not being able to satisfy their wants in regard to the quantity of cattle and other provisions, of which the poor inhabitants of Pulo Condore had scarcely any to supply, and consequently could not give the expected satisfaction. They therefore, through dread and apprehension, resolved to fly to preserve their lives. That they supplicate the great people to have pity on them; that they left all they had behind them, and only requested that their cabins might not be burnt; and conclude by prostrating themselves to the great people a hundred times.'

"The writers of this letter had probably received ill treatment from other strangers. It was determined that they should not continue to think ill of all who came to visit them. On their return they were perhaps as much surprised to find their houses still entire, as their visitors had been who found they were deserted. Nothing was disturbed; and a small present, likely to be acceptable to the chief, was left for him in the principal dwelling, with a Chinese letter, signifying that 'the ships and people were English, who called merely for refreshment, and on fair terms of purchase, without any ill intention; being a civilized nation, endowed with principles of humanity, which did not allow them to plunder or injure others who happened to be weaker or fewer than themselves."

Pulo Lingen, another of this cluster, is likewise a considerable island, remarkable for a mountain in its centre, terminating in a fork like Parnassus; but to which the unpoetical seamen bestow the name of *asses ears*. Every day presented new islands to the view, displaying a vast variety in form, size, and colour. Some isolated, and some collected in clusters. Many were clothed with verdure; some had tall trees growing on them; others were mere rocks, the resort of innumerable birds, and whitened with their dung.

PUNCTUATION, in grammar, is an art with which we have said, in the *Encyclopædia*, that the ancients were entirely unacquainted. Candour obliges us to confess that this was said rashly. A learned writer, in the Monthly Magazine for September 179[illegible], who subscribes J. Warburton, has proved, we think completely, that the art is not wholly modern; and we shall

shall lay his proofs, in his own words, before our readers.

"Some species of pauses and divisions of sentences in speaking and writing must have been coeval with the knowledge of communicating ideas by sound or by symbols. Suidas * says, that the *period* and the *colon* were discovered and explained by Thrasymacus, about 380 years before the Christian æra. Cicero † says, that Thrasymacus was the first who studied oratorical numbers, which entirely consisted in the artificial structure of periods and colons. It appears from a passage in Aristotle ‡, that punctuation was known in his time. The learned Dr Edward Bernard § refers the knowledge of pointing to the time of that philosopher, and says, that it consisted in the different positions of one single point. At the bottom of a letter, thus, (A.) it was equivalent to a comma; in the middle (A·) it was equal to a colon; at the top (A˙) it denoted a period, or the conclusion of a sentence.

* Qui primus periodum et colon monstravit *Suidas in Thrasymacho*.
† *Cicero Orat.* § 33.
‡ *Rhet* Lib iii c 5.
§ *Bern Orbis erud. Literat* tab 3. edit 1689.

"This mode was easily practised in Greek manuscripts, while they were written in capitals. But when the small letters were adopted, that is, about the 9th century, this distinction could not be observed; a change was therefore made in the scheme of punctuation. *Unciales literas hodierno usu dicimus eas in vetustis codicibus, quæ priscam formam servant, ac solutæ sunt, nec mutuo colligantur. Hujus modi literæ unciales observantur in libris omnibus ad nonum usque sæculum*—Montf. Palæog. Recens. p. xii.

"According to Cicero, the ancient Romans, as well as the Greeks, made use of points. He mentions them under the appellation of *librariorum notæ*; and in several parts of his works he speaks of '*interpunctæ clausulæ in orationibus*,' of '*clausulæ atque interpuncta verborum*,' of '*interpunctiones verborum*,' &c *.

"Seneca, who died A. D. 65, expressly says, that Latin writers, in his time, had been used to punctuation. '*Nos* †, *cum scribimus interpungere consuevimus*.' Muretus and Lipsius imagined that these words alluded to the insertion of a point after each word: but they certainly were mistaken; for they must necessarily refer to marks of punctuation in the division of sentences, because in the passage in which these words occur, Seneca is speaking of one Q. Haterius, who made no pauses in his orations.

* *Cic de Orat.* l. iii. § 2? ibid ? *Orat pro Murena*, § 25
† *Senec. Epist.*

"According to Suetonius, in his *Illust. Gram.* Valerius Probus procured copies of many old books, and employed himself in correcting, pointing, and illustrating them; devoting his time to this and no other part of grammar. *Multa exemplaria contracta emendare, ac distinguere et adnotare curavit; soli huic, nec ulli prætera, grammatices parti deditus*.

"It appears from hence, that in the time of Probus, or about the year 68, Latin manuscripts had not been usually pointed, and that grammarians made it their business to supply this deficiency.

"Quintilian, who wrote his celebrated treatise on Oratory, about the year 88, speaks of commas, colons, and periods; but it must be observed, that by these terms he means clauses, members, and complete sentences, and not the marks of punctuation ‡.

"Ælius Donatus § published a treatise on Grammar in the 4th century, in which he explains the *distinctio*, the *media distinctio*, and the *subdistinctio*; that is, the use of a single point in the various positions already mentioned.

‡ *Quint.* l. ix. c. 4.
§ A. D. 340.

"Jerom *, who had been the pupil of Donatus, in his Latin Version of the Scriptures, made use of certain distinctions or divisions, which he calls *cola* and *commata*. It has, however, been thought probable, that these divisions were not made by the addition of any points or stops; but were formed by writing, in one line, as many words as constituted a clause, equivalent to what we distinguish by a comma or a colon. These divisions were called στίχοι or ῥήματα; and had the appearance of short irregular verses in poetry. There are some Greek manuscripts still extant, which are written in this manner †."

* *Hieron. Præf in Esaiam. Vide etiam. Præf. in Josuam*, &c tom.iii. p. 26.
† *Vide Montf. Palæog. Græca*, lib. iii. c. 4.

Mr Warburton says, that the best treatise upon punctuation that he has seen, was published some years since by an anonymous author, and dedicated to Sir Clifton Wintringham, Bart. With that treatise we are not acquainted; but we do not think that the art of punctuation can be taught by rules. The only way to acquire it is to observe attentively how the most perspicuous writers dispose of their periods, colons, semicolons, and commas. This will make us acquainted with the importance of each; and then every writer, who knows his own meaning, must be capable of pointing his own pages more correctly than any other man.

PYRAMIDOID, is sometimes used for the parabolic spindle, or the solid formed by the rotation of a semiparabola about its base or greatest ordinate. See PARABOLIC *Spindle*.

PYRITES. See MINERALOGY in this *Suppl.*—In the third volume of Mr Nicholson's Philosophical Journal, we have a method of making artificial pyrites, which we shall give in the words of the author.

"I impregnated water (says he) very strongly with carbonic acid, and introducing some iron filings, I continued the impregnation for a day or two, and afterwards allowed the water to stand in a well corked bottle for some days, till the acid had taken up as much iron as possible. I then poured it into an aerating apparatus; threw up the hepatic gas from sulphuret of potash and sulphuric acid; and after having agitated the water till it had got a good dose of the gas, I poured the water into a large bason: this was in the evening, and next morning when I looked at it I found it covered with a pretty thick film of a most beautiful variegated pyrites. I had so little of it, that the only proof I had of its being this substance was, that it was ignited on its being placed on a hot poker."

QUADRATURE,

Q.

Quadrature.

QUADRATURE, in geometry (fee that article, and likewife FLUXIONS, *Encycl.*), has employed the time and ingenuity of fome of the moft eminent mathematicians both of ancient and of modern times. Dr Halley's method of computing the ratio of the diameter of the circle to its circumference, was confidered by himfelf, and other learned mathematicians, as the eafieft the problem admits of. And although, in the courfe of a century, much eafier methods have been difcovered, ftill a celebrated mathematician of our own times has expreffed an opinion, that no other aliquot part of the circumference of a circle can be fo eafily computed by means of its tangent as that which was chofen by Dr Halley, viz. the arch of 30 degrees. Without taking upon him to determine whether this opinion be juft or not, the Rev. John Hellins has fhewn how the feries by which Dr Halley computed the ratio of the diameter to the circumference of the circle may be transformed into others of fwifter convergency, and which, on account of the fucceffive powers of $\frac{1}{10}$ which occur in them, admit of an eafy fummation. We fhall give the memoir in the author's own words.

"1. The propofed transformation is obtained by means of different forms in which the fluents of fome fluxions may be expreffed; and to proceed with greater clearnefs, "I will here (fays Mr Hellins) fet down the fluxion in a general form, and its fluent, in the two feries which are ufed in the following particular inftance, and may be applied with advantage in fimilar cafes.

"2. The fluent of $\frac{x^{m-1}\dot{x}}{1-x^n}$ is $= \frac{x^m}{m} + \frac{x^{m+n}}{m+n} + \frac{x^{m+2n}}{m+2n} + \frac{x^{m+3n}}{m+3n}$, &c. which feries, being of the fimpleft form which the fluent feems to admit, was firft difcovered, and probably is the moft generally ufeful. But it has alfo been found, that the fluent of the fame fluxion may be expreffed in feries of other forms, which, though lefs fimple than that above written, yet have their particular advantages. Amongft thofe other forms of feries which the fluent admits of, that which fuits my prefent purpofe is $\frac{x^m}{m.\overline{1-x^n}} - \frac{nx^{m+n}}{m.\overline{m+n}.\overline{1-x^n}|^2} + \frac{n.2n.x^{m+2n}}{m.\overline{m+n}.\overline{m+2n}.\overline{1-x^n}|^3} - \frac{n.2n.3n.x^{m+3n}}{m.\overline{m+n}.\overline{m+2n}.\overline{m+3n}.\overline{1-x^n}|^4}$ + &c. which, to fay nothing of other methods, may eafily be inveftigated by the rule given in p. 64. of the third edition of *Emerfon's Fluxions*; or its equality with the former feries may be proved by algebra.

"3. On account of the fign — before x^n, in the laft feries, it may be proper to remark, that its convergency, by a geometrical progreffion, will not ceafe till $\frac{x^n}{1-x^n}$ becomes $= 1$, or x becomes $= \sqrt[n]{\frac{1}{2}}$; and that when x is a fmall quantity, and n a large number, this feries will converge almoft as fwiftly as the former. For inftance, if x be $= \sqrt{\frac{1}{3}}$, and $n = 8$, which are the values in the following cafe, the former feries will converge by the quantity $x^n = \sqrt{\frac{1}{3}}|^8 = \frac{1}{81}$, and this feries by the quantity $\frac{x^n}{1-x^n} = \frac{\frac{1}{81}}{1-\frac{1}{81}} = \frac{1}{80}$; where the difference in convergency will be but little, and the divifions by 80 eafier than thofe by 81.

"4. With refpect to the indices m and n, as they are here fuppofed to be affirmative whole numbers, and will be fo in the ufe I am about to make of them. the reader need not be detained with any obfervations on the cafes in which thefe fluents will fail, when the indices have contrary figns.

"5. It may be proper further to remark, that by putting $\frac{x^n}{1-x^n} = z$, and calling the firft, fecond, third, &c. terms of the feries $\frac{x^m}{m.\overline{1-x^n}} - \frac{nx^{m+n}}{m.\overline{m+n}.\overline{1-x^n}|^2} + \frac{n.2nx^{m+2n}}{m.\overline{m+n}.\overline{m+2n}.\overline{1-x^n}|^3}$ + &c. A, B, C, &c. refpectively, the feries will be expreffed in the concife and elegant notation of Sir Ifaac Newton, viz. $\frac{x^m}{m.\overline{1-x^n}} - \frac{nzA}{m+n} + \frac{2nzB}{m+2n} - \frac{3nzC}{m+3n}$ + &c. which is well adapted to arithmetical calculation.

"6. I come now to the transformation propofed, which will appear very eafy, as foon as the common feries, expreffing the length of an arch in terms of its tangent, is properly arranged.

"If the radius of a circle be 1, and the tangent of an arch of it be called t, it is well known that the length of that arch will be $= t - \frac{t^3}{3} + \frac{t^5}{5} - \frac{t^7}{7} + \frac{t^9}{9} - \frac{t^{11}}{11}$ + &c. Now, if the affirmative terms of this feries be written in one line, and the negative ones in another, the arch will be

$$= \begin{cases} t + \frac{t^5}{5} + \frac{t^9}{9} + \frac{t^{13}}{13} + \frac{t^{17}}{17} + \text{\&c.} \\ -\frac{t^3}{3} - \frac{t^7}{7} - \frac{t^{11}}{11} - \frac{t^{15}}{15} - \frac{t^{19}}{19} - \text{\&c.} \end{cases}$$

And if, again, the firft, third, fifth, &c. term of each of thefe feries be written in one line, and the fecond, fourth, fixth, &c. in another, the fame arch will be expreffed thus:

$$= \begin{cases} + \begin{cases} t + \frac{t^9}{9} + \frac{t^{17}}{17} + \frac{t^{25}}{25} + \frac{t^{33}}{33} + \text{\&c.} \\ \frac{t^5}{5} + \frac{t^{13}}{13} + \frac{t^{21}}{21} + \frac{t^{29}}{29} + \frac{t^{37}}{37} + \text{\&c.} \end{cases} \\ - \begin{cases} \frac{t^3}{3} + \frac{t^{11}}{11} + \frac{t^{19}}{19} + \frac{t^{27}}{27} + \frac{t^{35}}{35} + \text{\&c.} \\ \frac{t^7}{7} + \frac{t^{15}}{15} + \frac{t^{23}}{23} + \frac{t^{31}}{31} + \frac{t^{39}}{39} + \text{\&c.} \end{cases} \end{cases}$$

All which feries are evidently of the firft form [illegible] ticle 2. and therefore their values may be expreffed in the fecond form there given, or more neatly the Newtonian notation mentioned in art. 5. In each of thefe feries the value of n is 8:

And the value of m, $\begin{cases} \text{in the first series, is } 1; \\ \text{in the second series, is } 5; \\ \text{in the third series, is } 3; \\ \text{in the fourth series, is } 7. \end{cases}$

"If now we take $t = \sqrt{\frac{1}{3}}$, the tangent of 30°, which was chosen by Dr Halley, we shall have the arch of 30°

$$= \begin{cases} + \begin{cases} \frac{1}{\sqrt{3}} \times : 1 + \frac{1}{9.81} + \frac{1}{17.81^2} + \frac{1}{25.81^3} + \frac{1}{33.81^4}, \text{ \&c.} \\ \frac{1}{9\sqrt{3}} \times : \frac{1}{5} + \frac{1}{13.81} + \frac{1}{21.81^2} + \frac{1}{29.81^3} + \frac{1}{37.81^4}, \text{ \&c.} \end{cases} \\ - \begin{cases} \frac{1}{3\sqrt{3}} \times : \frac{1}{3} + \frac{1}{11.81} + \frac{1}{19.81^2} + \frac{1}{27.81^3} + \frac{1}{35.81^4}, \text{ \&c.} \\ \frac{1}{27\sqrt{3}} \times : \frac{1}{7} + \frac{1}{15.81} + \frac{1}{23.81^2} + \frac{1}{31.81^3} + \frac{1}{39.81^4}, \text{ \&c.} \end{cases} \end{cases}$$

Six times this quantity will be = the semicircumference when radius is 1, and = the whole circumference when the diameter is 1. If therefore we multiply the last series by 6, and write $\sqrt{12}$ for $\frac{6}{\sqrt{3}}$, and express their value in the form given in art. 5. we shall have the circumference of a circle whose diameter is 1,

$$= \begin{cases} + \begin{cases} \frac{81\sqrt{12}}{80} - \frac{8A}{9.80} + \frac{16B}{17.80} - \frac{24C}{25.80} + \frac{32D}{33.80}, \text{ \&c.} \\ \frac{81\sqrt{12}}{5.9.80} - \frac{8A}{13.80} + \frac{16B}{21.80} - \frac{24C}{29.80} + \frac{32D}{37.80}, \text{ \&c.} \end{cases} \\ - \begin{cases} \frac{81\sqrt{12}}{3.3.80} - \frac{8A}{11.80} + \frac{16B}{19.80} - \frac{24C}{27.80} + \frac{32D}{35.80}, \text{ \&c.} \\ \frac{81\sqrt{12}}{7.27.80} - \frac{8A}{15.80} + \frac{16B}{23.80} - \frac{24C}{31.80} + \frac{32D}{39.80}, \text{ \&c.} \end{cases} \end{cases}$$

"7. All these new series, it is evident, converge somewhat swifter than by the powers of 80. For in the first series, which has the slowest convergency, the coefficients $\frac{8}{9}$, $\frac{16}{17}$, $\frac{24}{25}$, &c. are each of them less than 1; so that its convergency is somewhat swifter than by the powers of 80.

"8. But another advantage of these new series is, that the numerator and denominator of every term except the first, in each of them, is divisible by 8; in consequence of which, the arithmetical operation by them is much facilitated, the division by 80 being exchanged for a division by 10, which is no more than removing the decimal point. These series, then, when the factors which are common to both numerators and denominators are expunged, will stand as below (each of which still converging somewhat quicker than by the powers of 80), and we shall have the circumference of a circle whose diameter is 1,

$$= \begin{cases} + \begin{cases} \frac{81\sqrt{12}}{80} - \frac{A}{9.10} + \frac{2B}{17.10} - \frac{3C}{25.10} + \frac{4D}{33.10}, \text{ \&c.} \\ \frac{9\sqrt{12}}{400} - \frac{A}{13.10} + \frac{2B}{21.10} - \frac{3C}{29.10} + \frac{4D}{37.10}, \text{ \&c.} \end{cases} \\ - \begin{cases} \frac{9\sqrt{12}}{80} - \frac{A}{11.10} + \frac{2B}{19.10} - \frac{3C}{27.10} + \frac{4D}{35.10}, \text{ \&c.} \\ \frac{3\sqrt{12}}{7.80} - \frac{A}{15.10} + \frac{2B}{23.10} - \frac{3C}{31.10} + \frac{4D}{39.10}, \text{ \&c.} \end{cases} \end{cases}$$

"By which series the arithmetical computation will be much more easy than by the original series."

Quadrature Lines, or *Lines of Quadrature*, are two lines often placed on Gunter's sector. They are marked with the letter Q, and the figures 5, 6, 7, 8, 9, 10; of which Q denotes the side of a square, and the figures denote the sides of polygons of 5, 6, 7, &c. sides. Also S denotes the semidiameter of a circle, and 90 a line equal to the quadrant or 90° in circumference.

QUADRIPARTITION, is the dividing by 4, or into four equal parts. Hence *quadripartite*, &c, the 4th part, or something parted into four.

QUADRUPLE, is four fold, or something taken four times, or multiplied by 4; and so is the converse of quadripartition.

QUART, a measure of capacity, being the quarter or 4th part of some other measure. The English quart is the 4th part of the gallon, and contains two pints. The Roman quart, or quartarius, was the 4th part of their congius. The French, besides their quart or pot of two pints, have various other quarts, distinguished by the whole of which they are quarters; as *quart de muid*, and *quart de boisseau*.

QUARTILE, an aspect of the planets when they are at the distance of three signs or 90° from each other; and is denoted by the character □.

QUELPAERT, an island lying in the mouth of the channel of Japan, and subject to the king of Corea (See that article *Encycl.*) Till the last voyage of La Perouse, this island was known to Europeans only by the wreck of the Dutch ship Sparrow-hawk in 1635. On the 21st of May 1787, the French Commodore made this island, and determined the south point of it to be in Lat. 33° 14′ north, and in Lon. 124° 15′ east from Paris. He ran along the whole south east side, at six leagues distance, and says that it is scarcely possible to find an island which affords a finer aspect; a peak of about a thousand toises, which is visible at the distance of eighteen or twenty leagues, occupies the middle of the island, of which it is doubtless the reservoir; the land gradually slopes towards the sea, whence the habitations appear as an amphitheatre. The soil seemed to be cultivated to a very great height. By the assistance of glasses was perceived the division of fields; they were very much parcelled out, which is the strongest proof of a great population. The very varied gradation of colours, from the different states of cultivation, rendered the view of this island still more agreeable. Unfortunately, it belongs to a people who are prohibited from all communication with strangers, and who detain in slavery those who have the misfortune to be shipwrecked on these coasts. Some of the Dutchmen of the ship Sparrow-hawk, after a captivity of eighteen years there, during which they received many bastinadoes, found means to take away a bark, and to cross to Japan, from which they arrived at Batavia, and afterwards at Amsterdam.

QUEUE D'ARONDE, or *Swallow's Tail*, in fortification, is a detached or outwork, whose sides spread or open towards the campaign, or draw narrower and closer towards the gorge. Of this kind are either single or double tenailles, and some horn-works, whose sides are not parallel, but are narrow at the gorge, and open at the head, like the figure of a swallow's tail. On the contrary, when the sides are less than the gorge, the work is called *contre queue d'aronde*.

Queue, Quintal

Queue d'aronde, in carpentry, a method of jointing, called also *dove-tailing*.

QUINTAL, the weight of a hundred pounds, in most countries: but in England it is the hundred weight, or 112 pounds. Quintal was also formerly used for a weight of lead, iron, or other common metal, usually equal to a hundred pounds, at 6 score to the hundred.

Quintile

QUINTILE, in astronomy, an aspect of the planets when they are distant the 5th part of the zodiac, or 72 degrees; and is marked thus, C, or Q.

R.

Rachitis.

RACHITIS, Rickets (See Medicine-*Index*, *Encycl.*), is a disease so formidable to children, that we believe no parent will think the following abstract of *Bonhomme's* memoir on the nature and treatment of it too long even for this *Supplement*.

The change which the bones undergo in this disorder, has long been attributed to the action of an acid on their substance; but this supposition was grounded on mere conjecture and remote analogy. Bonhomme holds the same opinion on better grounds; and the principal notions which constitute the basis of his memoir are the following:

1. According to him, the nature of the rachitic disorder arises, on the one hand, from the developement of an acid approaching in its properties to the vegetable acids, particularly the oxalic; and, on the other, from the defect of phosphoric acid, of which the combination with the animal calcareous earth forms the natural basis of the bones, and gives them their solidity. Whence it follows, that the indication resulting from this proposition, if once adopted, would be, that the treatment of rachitis must depend on two principal points, namely, to prevent the developement of the oxalic acid, and to re-establish the combination of the phosphoric acid with the basis of the bones to which they owe their solidity.

2. The author proves, by experiments and observations, in the first place, that alkaline lotions of the parts affected with rachitis contribute to their cure; next, that the calcareous phosphate taken internally is really transmitted by the lymphatic passages, and contributes to ossification; and, lastly, that the internal use of calcareous phosphate, whether alone or combined with the phosphate of soda, powerfully contributes to restore the natural proportions in the substance of the bones, and accelerate the cure of rachitis.

With regard to the author's endeavours to prove that the calcareous acid is wanting in the bones of those who are disordered with rachitis, and that the developement of oxalic acid contributes to the disease, we must not conceal that his memoir contains views rather than absolute proofs of these two positions. He declares, himself, he was not provided with the necessary means to establish an exact and complete analysis. He therefore presents his ideas, in this respect, merely as conjectures approaching to the truth.

The effect of the action of acids upon bones was before known; that is to say, that when deprived of calcareous phosphate, and reduced to the gelatinous parenchyma which forms one of their elements, they lose their consistence, and become flexible. Hence it was already conjectured by various physicians, that the rachitis was the effect of a peculiar acid.

Rachitis.

A disposition to acescence in the first passages is observable in all infants. The odour which characterizes this acescence is often manifest in their breath, and even their perspiration. The bile corrects this disposition; but in general the bile is wanting in rachitic infants. It does not colour their excrements, and the acids accordingly are developed in a very decided manner. They disturb the circulation, and attack and soften the bones. As it is by defect of animalization that these acids develope themselves, it follows that their character is analogous to the fermentescible vegetable acids, and more or less to the oxalic acid; and that, on the contrary, the animal acid or phosphoric acid ceases to be formed, and to unite with the animal calcareous earth; whence they are deprived of the principle of their solidity. This is the theory of Citizen Bonhomme.

In order to establish this doctrine upon precise experiments, it was requisite to analyse rachitic bones comparatively with those of healthy individuals of the same age; and as it is known that the urine of rachitic subjects deposites a great quantity of a substance of sparing solubility and earthy appearance, it would have been advantageous to have joined a complete analysis of this urine and its sediment. Citizen Bonhomme, not being provided with the means sufficient to make these analyses, and being besides of opinion that such rachitic bones as are destroyed by this malady exist in a progressive state of change, which might render their analysis scarcely susceptible of comparison, limited himself to a collection of some of the most remarkable phenomena of the urine, of the aged, the adult, and infants in the healthy state, of infants in the rachitic state, and of patients after the perfect cure of this disorder. From these observations he has deduced several important results.

It is known, that when the urine contains disengaged phosphoric acid, as happens to aged individuals, and in some peculiar circumstances of the system, if lime water be poured in, there is a speedy deposition of calcareous phosphate. It is also known, that when a solution of the nitrate of mercury is poured to the fresh urine of adults, a rose-coloured precipitate is formed, which is a phosphate of mercury produced by the decomposition of the phosphates contained in the urine. These two proofs are therefore extremely proper to ascertain the presence of phosphoric acid, whether free or combined, in

in a fluid which in its natural state contains a remarkable proportion. Besides this principle, the urine deposits more or less of sediment, either gelatinous or of an earthy appearance; and, lastly, by evaporation, a saponaceous and saline extract, in greater or less abundance, is obtained by evaporation. By means of these four methods of examination, the author has ascertained the following facts:

1. In the healthy state, the sediment naturally deposited by urine is almost totally gelatinous in the infant and the adult, and in the aged individual it is surcharged with an abundant sediment of an earthy appearance similar to the earth of bones, which consequently is calcareous phosphate. 2. The quantity of brown saponaceous saline extract afforded by evaporation is greater in proportion to the age. 3. The presence of disengaged phosphoric acid, as shewn by lime water, is none in the urine of infants, scarcely perceptible in that of adults, but very remarkable in that of old men. For two ounces of this last urine afforded by this means ten grains of phosphate of lime. 4. The decomposition of the phosphates by nitrate of mercury is not seen in the urine of infants; an abundant precipitate of a light rose colour is produced in this way from the urine of adults; and in that of old men this precipitate is always of a grey colour, and very abundant. Hence Citizen Bonhomme concludes, that the phosphoric acid, whether at liberty or combined, does exist in the urine of healthy individuals in proportion to the destruction of the solids by age, and that it increases with the age.

With regard to the urine of rachitic subjects, the most remarkable facts are, 1. The abundant and apparently earthy sediment it deposits (spontaneously) is different from that of old men, by its colour, which is grey, and does not resemble phosphate of lime, and also by its much greater quantity. For a pound of this urine let fall two gros, whereas the same quantity of the urine of old men deposited only 45 grains. 2. The extract left by evaporation is likewise much more considerable than in other urine. It is one-third more in quantity than the extract afforded even by the urine of aged persons.

From these two first observations it follows, that the solids in rachitic subjects are destroyed with much more rapidity than even in old men; and that they afford a much more abundant portion of waste to the urine.

3. The light deposition occasioned by lime water in the urine of rachitic subjects is very small in quantity, brown, gelatinous when fresh, and pulverulent when dry. It does not at all resemble calcareous phosphate. 4. The deposition formed by the solution of mercurial nitrate is not abundant, neither of a rose colour as in the urine of adults, nor grey like that of old men. It is always white, and consequently has no external resemblance to the phosphate of mercury. The author affirms that it resembles a mercurial oxalate. Lastly, the urine of the same rachitic subjects when cured, exhibits again all the characters observed in the urine of healthy children. We shall not add to the reflections of the author. In effect, though these first observations are curious, they are incomplete. We offer them to physicians simply as the elements of an investigation which it is of importance to continue and bring to perfection. We shall therefore proceed to the curative and experimental parts of the memoir.

One of the facts which it was of the utmost importance to establish, was the transition of the calcareous phosphate from the intestinal passages, into those of circulation and secretion. Fourcroy had already well ascertained that the serum of milk contains this salt naturally. Vauquelin had proved its existence, as well as that of pure soda, in the seminal fluid; but was it possible that it could pass unaltered from the stomach and intestines into the vessels which contain the blood and lymph? Could it by this means apply itself to the bones? This was to be ascertained by experiments; and the following are the experiments made by Bonhomme for that purpose. We give them in a translation of his own words.

"I caused (says he) several young fowls of the same incubation to be fed in different manners. Some received the usual food without any mixture; others received daily a certain quantity of calcareous phosphate mixed in the same paste as formed the support of the others; and, lastly, one of them was fed with variations in the use of the mixture: the calcareous phosphate was sometimes given and sometimes suspended. When these fowls, after two months, had acquired their ordinary growth, I examined and carefully compared the state of their bones. The progress of the ossification in the epiphyses was various according to the nature of the food the animal had received. The bones of the last fowl, which had received the phosphate only from time to time, were rather more advanced than the bones of those which had been fed without mixture. The bones of those fowls which had been habitually fed with the mixture were evidently more solid, and their epiphyses were much less perceptible. Simple inspection was sufficient to shew these differences when the bones were mixed together.

"I had fed several young fowls of the same incubation according to another plan. Some were fed on a simple paste, without mixture; for others it was mixed with pulverised madder-root; and a third composition was made of this last paste and calcareous phosphate. This was also given habitually to other fowls. When, after two months I examined the progress of ossification in the bones of these different animals, I easily perceived the red traces of the madder in the ossified parts of all those which had used it; but I observed, that the ossification was not more advanced by the simple mixture of this root than by the ordinary food: on the contrary, the bones of those fowls which had swallowed the phosphate mixed with madder were much more solid than the others. The red colour served admirably to distinguish the extremities of the long bones from their epiphyses. After an exact comparison, there could be no doubt of the efficacy of calcareous phosphate in favour of the progress of ossification. The virtue of the madder seemed confined to that of giving colour to the ossified parts."

From these experiments, it was natural to make the trial of calcareous phosphate in addition to the remedies made use of in the treatment of rachitic subjects. Here follows what the author himself says of two remarkable instances in which the calcareous phosphate was administered with success:

"The daughter of Mr Ranchon watch-maker, aged two years and a half, walked with a feeble and tottering pace, and the extremities of all her bones presented epiphyses very

 very prominent. In this situation she exhibited the appearance of imperfect rachitis, or the first period of this disorder. Alkaline lotions, which I immediately advised, were attended with a good effect. Her sleep became more firm; and as the first passages were in a good state, I gave, without internal preparation, one scruple of a mixture of equal parts of phosphate of lime and phosphate of soda twice a day. In the course of three weeks her legs were perfectly restored; and this amiable infant has ever since had the satisfaction to run with spirit and agility.

"A female infant, of the name of Boiard, aged four years, had experienced from her birth the most decided symptoms of rachitis. The protuberance of the epiphyses and tumefaction of the abdomen first indicated the disease. The impossibility of supporting herself and walking at the usual age confirmed these unfortunate symptoms. By degrees the glands of the neck and of the mesentery became swelled; the teeth were blackened, became carious, and were not replaced. This situation became still more afflicting by crises almost periodical at an interval of three or four weeks. At these afflicting periods, a fever of considerable strength, cardialgia, and even convulsions, particularly in the night, were observed. The termination of each paroxysm was announced or ascertained by abundant stools, and the evacuation of urine strongly charged with an earthy sediment. The imprudent exhibition of a purge at the beginning of one of these crises had nearly deprived the patient of her life. In this state it was that I beheld her for the first time in the month of January 1791. The alkaline lotion was the only remedy the mother adopted in the first instance, and it produced a remarkable effect. After eight days the infant was so much better as to be able to support herself. The remedy was then laid aside, and eight days afterwards the child was incapable of standing without support. The use of the alkaline solution being renewed, was attended with the same success, and its discontinuance was again followed by the complete return of all the symptoms. In the first days of March, the other remedies I had advised were exhibited. The constipation which had always existed became less, and the following crisis was effected without pain. And at length the convulsions, the pains, and the crises disappeared; but the impossibility of walking still remained. At this time, namely on the second of May, I gave the child the phosphate of soda and calcareous phosphate mixed together, in the dose of half a dram twice a-day. At the end of the month she was able to stand upright, leaning against a chair, and the swellings began to diminish. She continued for a long time afterwards to take the mixture of the phosphates. I likewise gave her occasionally one grain of the extract of bile, prepared with spirit of wine; and at length in the month of July I had the pleasure to see the patient run and play in the middle of the street with the other children of her own age, &c."

The author gives other instances of this medicine being administered with complete success to rachitic children, and one in which it was attended with the best effects in a case of incurvated spine. These it is needless to insert, because we trust that none of our less learned readers will have recourse to the medicine without the advice of a physician; and to him an enumeration of cases could serve no purpose. It may be proper, however, as alkaline lotions and their beneficial effects are mentioned, to give here the author's account of the lotion which he used.

"In ordinary cases of rachitis, particularly at the commencement of the disorder, it is of advantage to use a simple solution of pot-ash to wash the parts affected. This solution is made by dissolving from half an ounce to an ounce of purified pot-ash in a pound of distilled or very pure spring water. When it is to be used, the skin must first be rubbed with a dry cloth or a piece of fine flannel. After this precaution, the diseased extremities are to be washed carefully with the warm solution, and at length wiped, so as to leave no trace of moisture. This practice and washing must be repeated at least twice a-day. I can affirm, from repeated trials, that it will always be attended with success."

In a note on this passage, M. Hallé, who analysed the memoir at the desire of the Society of Medicine at Paris, justly observes, that as pure potash, or the vegetable alkali, is a most powerful caustic, it cannot be used in these proportions; adding, that he found one-eighth part of the salt here indicated to form too strong a lotion for the skin of an infant. M. Bonhomme, upon enquiry being made, informed him, that the potash which he used was that of the shops, which is very far from being pure; and Mr Nicholson conjectures that it was the common salt of tartar of our shops. This, we think, extremely probable, especially as M. Bonhomme assures us that even a lixium of wood ashes, such as is used for washing fine linen, may answer the purpose extremely well.

For a fuller account of this interesting memoir our readers are referred to the 17th volume of the *Annales de Chimie*, or to the first volume of *Nicholson's Philosophical Journal*.

RAJA, the *ray fish*. See *Encyclopædia*, where it is said that the *oxyrinchus* or sharp nosed ray, is supposed to be the *bos* of the ancients; but if there be any truth in the following narrative, which we confess has much the air of fiction, this is probably a mistake. It is the narrative of Vaillant, and we shall give it in his own words.

"In the latitude 10° 15′ north, and longitude 355, an enormous flat fish of the ray genus (says he), came and swam round our vessel. It differed from the common ray, however, in the shape of its head, which, instead of being pointed, formed a crescent, and from the extremities of the semicircle issued two arms as it were, which the sailors called horns. They were two feet wide at the base, and only five inches at the extremity. This monster they told me was called the *sea-devil*.

"A few hours after, we saw two others with this, one of which was so extremely large, that it was computed by the crew to be *fifty* or *sixty* feet wide. Each swam separately, and was surrounded by those small fish which usually precede the shark, and which are therefore called by seamen *pilot-fish*. Lastly, all three carried on each of their horns a white fish, about the size of a man's arm, and half a yard long, which appeared to be stationed there on duty.

"You would have said they were two sentinels placed to keep watch for the safety of the animal, to inform him of any approaching danger, and to guide his movements. If he approached too near the vessel, they quitted their posts, and, swimming briskly before, led him

him away. If he rose too high above the water, they passed backward and forward over his back till he had descended deeper. If, on the contrary, he swam too low, they disappeared, and we saw no more of them, because, no doubt, they were passing underneath, as in the preceding instance they had passed above him. Accordingly we found him reascend towards the surface, and then the two sentinels reassumed their posts, each on his horn."

These manœuvres continued three days; and to give our author the better opportunity of observing them, the ship most fortunately was becalmed the whole time. He was naturally very desirous of catching one of them that he might examine it at leisure; and, by bribing the seamen with a dozen of bottles of wine, he accomplished his object. One of the fish was struck with twelve or fifteen harpoons; several halsers were passed round his body, and he was hoisted on board.

"This (says our author) was the least of the three, being only *eight-and-twenty* feet in its extreme breadth, and *one-and-twenty* in length from the extremity of the horns to that of the tail. The tail, which was thick in proportion to the body, was *twenty-two inches* long. The mouth, placed exactly like that of the ray, was wide enough to swallow a man with ease. The skin was white under the belly, and brown on the back, like that of the ray. We reckoned the animal to weigh not less, certainly, than a ton."

We think it was fortunate that they chanced to strike the smallest fish; for an addition of eight or ten ton weight, which the largest ray must have weighed, as certainly as the smallest weighed one ton, might have been very inconvenient on board a ship already loaded. We do not remember to have anywhere met with a description of this ray before, and we think it should be considered as a new species; but we shall not give it a name till its existence be better ascertained, when we submit to the pupils of Linnæus, whether it may not be proper to give it the ancient name *bos*.

RAJAH. (See *Encyclopædia*.) We learn from Sir Charles Rouse Boughton's *Dissertation concerning the Landed Property of Bengal*, that this title is conferred upon Hindoos by the emperor, and frequently given out of courtesy to the greater zemindars. It would appear therefore that the Rajahs can never be independent of the Mogul but by a successful rebellion.

RAYEL-UL-MULK, in the language of Bengal, the usage of the country, the common law.

RATIO (See *Encyclopædia*) has been defined by Euclid, in the 5th book of his Elements, in terms to which many mathematicians have objected; and his definition of proportion, which is so ultimately connected with it, is still more objectionable. The Rev. Abraham Robertson of Oxford, in a small tract published in 1789, demonstrates the truth of the two definitions in question in seven propositions, of which the substance is as follows He first lays down these four definitions:

"1. Ratio is the relation which one magnitude has to another, of the same kind, with respect to quantity.

"2 If the first of four magnitudes be exactly as great when compared to the second, as the third is when compared to the fourth, the first is said to have to the second the same ratio that the third has to the fourth.

3. If the first of four magnitudes be greater, when compared to the second, than the third is when compared to the fourth, the first is said to have to the second a greater ratio than the third has to the fourth.

"4. If the first of four magnitudes be less, when compared to the second, than the third is when compared to the fourth, the first is said to have to the second a less ratio than the third has to the fourth."

He then demonstrates, by reasoning strictly geometrical, the following propositions:

Prop. 1. If the first of four magnitudes have to the second, the same ratio which the third has to the fourth; then, if the first be equal to the second, the third is equal to the fourth; if greater, greater; if less, less.

Prop. 2. If the first of four magnitudes be to the second as the third to the fourth, and if any equimultiples whatever of the first and third be taken, and also any equimultiples of the second and fourth; the multiple of the first will be to the multiple of the second as the multiple of the third to the multiple of the fourth.

Prop. 3. If the first of four magnitudes be to the second as the third to the fourth, and if any like aliquot parts whatever be taken of the first and third, and any like aliquot parts whatever of the second and fourth, the part of the first will be to the part of the second as the part of the third to the part of the fourth.

Prop. 4. If the first of four magnitudes be to the second as the third to the fourth, and if any equimultiples whatever be taken of the first and third, and any whatever of the second and fourth; if the multiple of the first be equal to the multiple of the second, the multiple of the third will be equal to the multiple of the fourth; if greater, greater; if less, less.

Prop. 5. If the first of four magnitudes be to the second as the third is to a magnitude less than the fourth, then it is possible to take certain equimultiples of the first and third, and certain equimultiples of the second and fourth, such, that the multiple of the first shall be greater than the multiple of the second, but the multiple of the third not greater than the multiple of the fourth.

Prop. 6. If the first of four magnitudes be to the second as the third is to a magnitude greater than the fourth, then certain equimultiples can be taken of the first and third, and certain equimultiples of the second and fourth, such, that the multiple of the first shall be less than the multiple of the second, but the multiple of the third not less than the multiple of the fourth.

Prop. 7. If any equimultiples whatever be taken of the first and third of four magnitudes, and any equimultiples whatever of the second and fourth; and if when the multiple of the first is less than that of the second, the multiple of the third is also less than that of the fourth; or if when the multiple of the first is equal to that of the second, the multiple of the third is also equal to that of the fourth; or if when the multiple of the first is greater than that of the second, the multiple of the third is also greater than that of the fourth: then, the first of the four magnitudes shall be to the second as the third to the fourth.

RATIONAL, in arithmetic, &c. the quality of numbers, fractions, quantities, &c. when they can be expressed by common numbers; in contradistinction to irrational or surd ones, which cannot be expressed in common numbers.

RAYNAL (William Thomas), commonly called the Abbé Raynal, was educated among the Jesuits, and had become one of the order. The learning of that Society is universally

Raynal univerſally known, as well as the happy talents which its ſuperiors poſſeſſed, of aſſigning to each member his proper employment. Raynal, however, after having acquired among them a taſte for literature and ſcience, had probably become refractory, for he was expelled from the order; and the cauſe of his expulſion, according to the Abbé Barruel, was his impiety.

With the real cauſe of his expulſion M. Barruel is ſurely much better acquainted than we can pretend to be; but we have a ſtrong ſuſpicion that his impieties had not then reached farther than to call in queſtion the ſupreme authority of the church; for our author himſelf aſſures us, that he did not utter his atrocious declarations againſt Chriſtianity till he had ceaſed to be a member of the order of Jeſuits. He then aſſociated himſelf with Voltaire, D'Alembert, and Diderot, and was by them employed to furniſh the theological articles for the *Encyclopedie*. But though his religious opinions were certainly lax, and his moral principles very exceptionable, he could not even then be what, in a Proteſtant country, would be deemed a man remarkable for impiety; for he employed the Abbé Yvon, whom M. Barruel calls an odd metaphyſician, but an inoffenſive and upright man, to write the articles which he was engaged to furniſh. In the conducting of this tranſaction, he ſhewed, indeed, that he poſſeſſed not a proper ſenſe of honour; for he paid poor Yvon with twenty-five louis d'ors for writing theological articles, for which he received himſelf ſix times that ſum. This trick was diſcovered, Raynal was diſgraced, and compelled to pay up the balance to Abbé Yvon; but tho' he had thus ſhewn himſelf to be without honour, it is difficult to believe that he had yet proceeded ſo far as to blaſpheme Chriſt, ſince he had employed a Chriſtian divine to ſupply his place in the *Encyclopédie*.

His firſt work of eminence, and that indeed upon which his fame is chiefly built, is his "Political and Philoſophical Hiſtory of the European Settlements in the Eaſt and Weſt Indies." That this hiſtory is written in an animated ſtyle, and that it contains many juſt reflections, both political and philoſophical, is known to all Europe; for it has been tranſlated into every European language. Its beauties, however, are deformed by many ſentiments that are irreligious, and by ſome that are impure. It was followed, we think, in 1780, by a ſmall tract entitled "The Revolution of America;" in which the author pleads the cauſe of the revolted coloniſts with a degree of zeal, cenſures the conduct of the Britiſh government with a keenneſs of aſperity, and diſplays a knowledge of the principles and intrigues of the different factions which at that period divided the Engliſh nation, that ſurely was not natural to the impartial pen of a philoſophic foreigner. Hence he has been ſuppoſed to have been incited to the undertaking, and to have been furniſhed with part of his materials, by that deſperate faction which uniformly oppoſed the meaſures of Lord North, and ſecretly fomented the rebellion in America. Be this as it may, he propagated, both in this tract and in his hiſtory, a number of licentious opinions reſpecting government and religion, of which he lived to regret the conſequences.

A proſecution was inſtituted againſt him by the French government on account of his hiſtory of the Eaſt and Weſt Indies; but it was conducted with ſo little ſeverity, that he had ſufficient time to retire to the dominions of the King of Pruſſia, who afforded him the protection he Raynal ſolicited, although his Majeſty's character was treated by the author in his book with no great degree of veneration. Raynal alſo experienced the kindneſs of the Empreſs of Ruſſia; and it is not a little remarkable of this ſingular perſonage, that, although he was always ſevere in diſcuſſing the characters of princes, yet the moſt deſpotic among theſe heaped upon him many marks of favour and generoſity. The Abbé alſo received a very unuſual mark of reſpect from a Britiſh Houſe of Commons. It was once intimated to the ſpeaker that Raynal was a ſpectator in the gallery. The buſineſs was immediately ſuſpended, and the ſtranger conducted to a more convenient and honourable ſituation. How different was the conduct of Dr Johnſon, who, when a friend advanced to him with our author, ſaying, "Will you give me leave, Doctor, to introduce to you the Abbe Raynal?" turned on his heel, and vociferated, "No, Sir!" We are far from wiſhing to vindicate the rudeneſs of the ſage; but it was perhaps as proper as the politeneſs of the Houſe of Commons.

The great trait of Raynal's character was a love of liberty, which, in his earlier writings, he did not properly define; but when he lived to ſee ſome of the conſequences of this, in the progreſs of the French Revolution, he made one glorious effort to retrieve his errors. In the month of May 1791, he addreſſed to the conſtituent aſſembly one of the moſt eloquent, argumentative, and impreſſive letters that ever was written on any ſubject; a letter which, if the majority of them had not been intoxicated with their newly acquired conſequence, muſt have given ſome check to their mad career. After complimenting them upon what they had done, he proceeds thus: "I have long dared to ſpeak to kings of their duty; ſuffer me now to ſpeak to the people of their errors, and to their repreſentatives of the dangers which threaten us. I am, I own to you, deeply afflicted at the crimes which plunge this empire into mourning. Is it true that I am to look back with horror at myſelf for being one of thoſe who, by feeling a noble indignation againſt arbitrary power, may perhaps have furniſhed arms to licentiouſneſs? Do then religion, the laws, the royal authority, and public order, demand back from philoſophy and reaſon the ties which united them to the grand ſociety of the French nation, as if, by expoſing abuſes, and teaching the rights of the people and the duties of princes, our criminal efforts had broken thoſe ties? But, no!—never have the bold conceptions of philoſophy been repreſented by us as the ſtrict rule for acts of legiſlation.

"You cannot juſtly attribute to us what could only be the reſult of a falſe interpretation of our principles. Alas! now that I ſtand on the brink of the grave; now that I am about to quit this immenſe family, whoſe happineſs I have ardently deſired, what do I ſee around me? Religious troubles, civil diſſenſions, conſternation on the one hand, tyranny and audacity on the other; a government the ſlave of popular tyranny; the ſanctuary of the laws ſurrounded by unruly men, who alternately dictate or deſpiſe thoſe laws; ſoldiers without diſcipline; leaders without authority; miniſters without means; a king, the firſt friend of his people, plunged into bitterneſs, inſulted, menaced, ſtripped of all authority; and the public power no longer exiſting but

in clubs, in which ignorant and rude men dare to decide all political questions."

He then proceeds to prove, which he does very completely, that it was not the business of the assembly to abolish every ancient institution; that the genius of the French people is such, that they never can be happy or prosperous but under a well regulated monarchical government; and that, if they wished not the nation to fall under the worst kind of despotism—the despotism of a low faction, they must increase the power of the king. "Alas! (continues he) what are my sufferings, when in the heart of the capital, in the centre of knowledge, I see this misguided people welcome, with a ferocious joy, the most criminal propositions, smile at the recital of murder, and celebrate their crimes as conquests!"

He had then seen comparatively but little; but he lived to see more—to see his countrymen celebrate, as virtues, crimes, compared with which the atrocities of 1791 appear almost as harmless. Being stripped of all his property, which was large, by the robbers of the revolution, he died in poverty in March 1796, and in the 84th year of his age.

Besides the works which we have already mentioned, he wrote "A History of the Parliament of England," and a "History of the Stadholderate;" but these are both of them more remarkable for a specious style and loftiness of invention than for useful observation or solid argument. He wrote likewise "The History of the Divorce of Catharine of Arragon by Henry the Eighth," which is not so much a recital of, and commentary upon, the fact from which he takes the title, as it is an able picture of universal Europe at that period, of the views, interests, and power, of all the different potentates. At the time of his death he was preparing a new edition of all his works, in which were to be made many alterations; and he is said to have left among his manuscripts a "History of the Revocation of the Edict of Nantes," in four volumes; but it is also very certain, that, during the sanguinary reign of Robespierre, he burnt a great part of his papers.

REAPING, the well known operation of cutting corn either by the sickle or by the scythe. Reaping by the sickle is by much the most common practice, and that which, we believe, prevails universally in Scotland; yet the other method, where it is practicable, is certainly the least laborious, and by much the most expeditious. To the scythe, as an instrument of reaping, many objections are urged.

It is said that it shakes the ear, so that many of the grains are lost; that it lets the corn fall, after cutting it, in a confused and scattered state, so that either much of it is lost, or a great deal of time is consumed in gathering it together; that it can only be made use of in land which is very even and free from stones; that it does not leave sufficient length of stubble in the ground to lay the corn on when cut; that it mixes bad weeds with the corn, the seeds of which are sown the next year; and, lastly, that the use of the scythe is prejudicial to the health of the reaper.

These objections, however, are either of no weight, or they are made by those who are not acquainted with the scythes which have been adapted to this purpose, and with the proper manner of using them. With a good scythe, properly managed, the corn, after being cut, remains at first upright, and then falls very gently upon the rake fixed to the scythe, without any shake or jolt; or at least with less than that which it receives when reaped with a sickle. With respect to the loss of grain, that proceeds chiefly from the corn being too dry; consequently it should be reaped only upon proper days, and proper times of the day, which is much more easily done with the scythe than with the sickle, because the work is so much shorter. The stalks, kept together by the rake, may be laid upon the ground, or rather against the corn not yet cut, in so regular and collected a state, that those who gather and tie the sheaves, whether they are women or children, have nothing but their own negligence to accuse if any thing is left behind. When land is properly ploughed and harrowed, it is sufficiently even; and in such as is stony, the only precaution necessary is to keep the scythe a little higher in using it, that it may not strike against the stones. If the stubble left in the ground be short, the straw which is cut off will be the longer; and the latter is certainly of more value than the former, which only serves to incommode the cattle which afterwards go to feed in the field.

These considerations, and others of a like nature, induced the patriotic society of Milan to send, some years ago, to those parts in which scythes are made use of for reaping; and having procured a model of a scythe from Silesia, they caused one to be made of a proper size. It was first tried upon corn, and afterwards upon millet; and although the first scythe was not accurately made, and the reaper had never before made use of such an instrument, yet it was found that nearly half the usual time was saved, and that the labour and fatigue were much diminished; the corn also was cut without receiving any shock that could be hurtful to it, and fell in an even and regular state, so that it was afterwards easily bound up in compact sheaves. They were afterwards presented with a scythe somewhat different from the Silesian, which is very generally used in Austria.

These instruments are so simple, that the figure of one of them renders the description of either almost unnecessary. In fig. 1. is shewn the Silesian scythe tried by the Society; the difference between that and the Austrian one we shall mention in our description. The first, or Silesian scythe, differs very little from the scythe we commonly use for mowing grass, except that the blade is rather smaller; to it are added four teeth of wood, parallel to the blade, fixed and secured in a proper manner, and intended to keep the corn together after being cut, so that instead of its falling in a confused state, the reaper may lay it down in a regular and compact one. The second, or Austrian scythe, is similar to the former, except that the blade is larger; consequently the wooden teeth, of which there are five, are longer; the handle also is more flat, and rather crooked.

Plate XLII.

In the *first*, the handle *a b* (see fig. 1.) is two Milanese brasses (A), and nine inches and a half in length; the

(A) One hundred Milanese *brasses* are equal to fifty-eight English yards and a half.

Reaping-Rectification.

the blade $b c$ is one brass three inches and a half; the piece of wood in which the teeth are fixed, one brass one inch and a half. In the *second*, the handle is two brasses, and seven inches long; the blade, one brass eleven inches; the piece in which the teeth are fixed, eleven inches and a quarter. The proportions of the other parts may be conceived from the figure.

The difference in the construction of these two scythes makes it requisite to use them in a different manner; but that will be better acquired in practice than by precept. Such of our countrymen as are accustomed to the use of the common scythe will very soon find out the most convenient and advantageous manner of using these new kinds of scythe, and of laying down the corn properly when cut.

It should, however, be observed, that in mowing grass the feet are kept almost parallel to each other, whereas in reaping corn they should be kept upon a line, one behind the other, thrusting the right foot forward, and drawing the left towards it. This is necessary, because when grass is mowed it is left to fall just where it is cut; but when corn is cut, it is to be carried and laid in a proper manner against that which is not yet cut, and which is at the left band of the reaper; and if the feet were kept parallel to each other, the reaper would be obliged to extend and turn his body in a very inconvenient manner.

After having made public these observations, the society made farther experiments upon the subject, in which it was found, that when, on account of very wet weather, the stalks of the corn are bent down, the wooden teeth of the forementioned scythes are apt to lay hold of some ears, to the stalks of which the iron does not reach; and consequently not being cut below, they are pulled so that the grain is scattered. This happens chiefly when the reapers, not being yet sufficiently accustomed to that kind of scythe, do not know how to adapt it to particular circumstances.

To remedy this inconvenience, it occurred to an ingenious blacksmith to add to the common scythe a *gatherer* or *collector* made of cloth, as may be seen at fig. 2. where $a b c$ is a common scythe; [illegible] is the gatherer; which at $c d e$ is composed of a thin plate of iron, having at its extremity a hollow for receiving the point of the blade. At $e d$ are holes for sewing in the cloth, which is coarse, light, and of low price; it is also fixed to two thick iron wires, of which the upper one is continued to f, where it terminates in a hole in the handle; the other is fixed to the back of the blade. The manner of fixing this gatherer to the blade of the scythe will be better understood by referring to fig. 3. which represents one of the irons which, by means of a screw, are fastened to the back of the scythe. These irons proceed from, and make part of, the upright irons $m n$, $l o$, which serve to keep the gatherer extended.

This is a very simple and cheap contrivance; but an attempt was made to render it still more simple, by substituting for the gatherer two iron hoops, which are shown in fig. 2. by the dotted lines $h g$, $k i$, with a cross piece p which connects them. Experience, however, has shewn, that the gatherer is in general preferable to these hoops, as it does not leave an ear of corn behind.

RECTIFICATION OF ETHER, a process for depriving ether of its sulphureous acid (See CHEMISTRY, *Index* in this *Suppl.*) It has been usual to add an alkali for this purpose; but Dizé has found it much more advantageous to add a substance which might afford the requisite quantity of oxygen to convert the sulphureous into the sulphuric acid; in which state it is not disposed to rise and come over. Various metallic oxyds were tried, among which the black oxyd of manganese proved the best and the cheapest. His process is as follows:

Rectification, Turkey Red.

The sulphureous acid contained in unrectified ether being neutralized with oxyd of manganese, the fluid is decanted into a pewter vessel of the capacity of fifty ounces, which is placed on a water bath. To this vessel a head and worm are adapted, the latter of which passes through a refrigeratory constantly supplied with water in a stream from below, which causes the heated water to flow off above. The distillation is then performed by raising the bath to a temperature of [illegible] (113° Fahrenheit, if the decimal thermometer be here meant). The rectification by this treatment [illegible] requires a day to complete it. The flavour of the ether is of the best kind, and the product about one sixth more than in the usual method with retort and receiver. Dizé has practised this method with success for three years.—*Journal de Physique, April*, 179[illegible].

RECTIFICATION, in geometry, is the finding of a right line equal to a curve. The rectification of curves is a branch of the higher geometry, a branch in which the use of the inverse method of fluxions is especially useful.

TURKEY-RED, *Levant-Red*, and *Adrianople-Red*, the names indifferently given to that beautiful [illegible] which distinguishes the cotton manufactured in the Ottoman empire, and at *Astracan* in the dominions of Russia. We have two accounts of the process of communicating this dye to the stuffs; one by Professor Pallas as he saw it practised at Astracan; the other in the 92d number of the *Annales de Chimie* by Citizen Felix. As every thing relating to useful manufactures is of general importance, we shall give pretty copious extracts from both papers.

According to Dr Pallas, the dye stuffs employed at Astracan are, madder, sumach, gall-nuts, alum, an inferior kind of soda, and fish-oil. The process of dyeing is as follows:

The roots of the madder, when fresh gathered, are placed above each other in a stove, or in a pit dug in viscous earth which has been strongly heated. Earth is then thrown over the madder, and it must sweat until the stove or pit becomes cold; when the roots, the second or third day, are taken from it, and either spread out or hung up to dry. When it is thoroughly dried in the sun, the madder is ground to a very fine powder, as are likewise the round leaves of the sumach (*rhus cotinus*). The fish-oil is boiled from the entrails of the sturgeon and other large fishes; and the proof of its being proper for dyeing is, that when mixed with a lixivium of soda, it must immediately assume a milky appearance. Should that not be the case, it cannot be used by the dyers.

The cotton to be dyed red is first washed exceedingly clean in running water; and when the weather is clear, hung up on poles to dry. If it does not dry before the evening, it is taken into the house, on account of

Turkey-Red.

of the ſaline dews ſo remarkable in the country around Aſtracan, and again expoſed to the air next morning. When it is thoroughly dry it is laid in a tub, and fiſh-oil is poured over it till it is entirely covered. In this ſtate it muſt ſtand all night; but in the morning it is hung up on poles, and left there the whole day; and this proceſs is repeated for a week, ſo that the cotton lies ſeven nights in oil, and is expoſed ſeven days to the atmoſphere, that it may imbibe the oil, and free itſelf from all air. The yarn is then again carried to a ſtream, cleaned as much as poſſible, and hung up on poles to dry.

After this preparation a mordant is made of three materials, which muſt give the grounds of the red colour. The pulverized leaves of the ſumach are firſt boiled in copper kettles; and when their colouring matter has been ſufficiently extracted, ſome powdered galls are added, with which the liquor muſt be again boiled; and by theſe means it acquires a dark dirty colour. After it has been ſufficiently boiled the fire is taken from under the kettle, and alum put into the ſtill hot liquor, where it is ſoon diſſolved. The proportion of theſe three ingredients cannot be aſcertained, as the dyers vary that proportion at pleaſure. The powder of the ſumach leaves is meaſured into the kettle with ladles; the water is poured in according to a gauge, on which marks are made to ſhew how high the water muſt ſtand in the kettle to ſoak ſix, eight, ten, &c. puds of cotton yarn. The galls and alum are added in the quantity of five pounds to each pud of cotton. In a word, the whole mordant muſt be ſufficiently yellow, ſtrong, and of an aſtringent taſte.

As ſoon as the alum is diſſolved, no time muſt be loſt in order that the mordant may not be ſuffered to cool. The yarn is then put into hollow blocks of wood ſhaped like a mortar, into each of which ſuch a quantity of the mordant has been poured as may be ſufficient to moiſten the yarn without any of it being left. As ſoon as the workman throws the mordant into the mortar, he puts a quantity of the yarn into it, and preſſes it down with his hand till it becomes uniformly moiſtened, and the whole cotton yarn has ſtruck. By this it acquires only a pale yellow colour, which, however, is durable. It is then hung up on poles in the ſun to dry; again waſhed in the ſtream, and afterwards dried once more.

The next part of the proceſs is to prepare the madder dye. The madder, ground to a fine powder, is ſpread out in large troughs, and into each trough is poured a large cupful of ſheep's blood, which is the kind that can be procured with the greateſt facility by the dyers. The madder muſt be ſtrongly mixed in it by means of the hand, and then ſtand ſome hours in order to be thoroughly ſoaked by it. The liquor then aſſumes a dark red appearance, and the madder in boiling yields more dye.

After this proceſs water is made hot in large kettles, fixed in brickwork; and as ſoon as it is warm, the prepared red dye is put into it, in the proportion of a pound to every pound of cotton. The dye is then ſuffered to boil ſtrongly; and when it is enough, which may be tried on cotton threads, the fire is removed from under the kettle, and the prepared cotton is depoſited near it. The dyer places himſelf on the edge of the brickwork that incloſes the kettle; dips the cotton yarn, piece by piece, into the dye; turns it round backwards and forwards; preſſes it a little with his hands; and lays each piece, one after the other, in pails ſtanding ready for the purpoſe. As ſoon as all the cotton has received the firſt tint, it is hung up to dry; as the red, however, is ſtill too dull, the yarn, which has been already dyed once, and become dry, is put once more into the dyeing-kettle, and muſt be left there to ſeethe for three hours over a ſtrong fire; by which it acquires that beautiful dark red colour which is ſo much eſteemed in the Turkey yarn. The yarn is now taken from the dye with ſticks; the ſuperfluous dye which adheres to it is ſhaken off; the hanks are put in order, and hung up, one after another, to dry. When it is thoroughly dry, it is waſhed in the pure ſtream, and again dried.

Turkey-Red.

In the laſt place, the above mentioned ſoda is diſſolved with boiling water in tubs deſtined for that purpoſe, and it is uſual at Aſtracan to allow 20 pounds of ſoda to 40 pounds of cotton, or half the weight. Large earthen jars, which are made in Perſia of very ſtrong clay, a yard and a half in height, almoſt five ſpans wide in the belly, and ending in a neck a ſpan and a half in diameter, incloſed by means of cement in brickwork over a fire-place, in ſuch a manner that the necks only appear, are filled with the dyed cotton yarn. The ley of diſſolved ſoda, which is blackiſh and very ſharp, is then poured over it till the jars be filled; and ſome clean rags are preſſed into their mouths, that the uppermoſt ſkains of yarn may not lie uncovered. A fire is then made in the fire place below, and continued for 24 hours; and in the mean time the ſteam which ariſes from the jars is ſeen collected among the rags in red drops. By this boiling the dye is ſtill more heightened, and is made to ſtrike completely; every thing ſuperfluous is removed, and all the fat matter which ſtill adheres to the yarn is waſhed out. Nothing more is then neceſſary for completing the dye of the yarn but to rinſe it well ſeveral times in running water, and then to dry it.

Cotton cloth is dyed with madder at Aſtracan in the ſame manner; but many purſue a fraudulent proceſs, by dying with red wood, and then ſell their cloth as that which has been dyed in the proper manner.

The proceſſes followed in the Grecian manufactories in the Levant, as deſcribed by M. Felix, varies in ſome particulars from this. The firſt proceſs is that of cleaning the cotton: for which purpoſe three leys are employed; one of ſoda, another of aſhes, and a third of lime. The cotton is thrown into a tub, and moiſtened with the liquor of the three leys in equal quantities: it is then boiled in pure water, and waſhed in running water.

The ſecond bath given to the cotton is compoſed of ſoda and ſheep's dung diſſolved in water. To facilitate the ſolution, the ſoda and dung are pounded in a mortar. The proportions of theſe ingredients employed, are one occa of dung, ſix of ſoda, and forty of water; each occa being equal to about fifty ounces. When the ingredients are well mixed, the liquor expreſſed from them is ſtrained; and being poured into a tub, ſix occas of olive oil are added to it, and the whole is well ſtirred till it becomes of a whitiſh colour like milk. The cotton is then beſprinkled with this water; and when the ſkains are thoroughly moiſtened, they are wrung,

wrung, preſſed, and expoſed to dry. The ſame bath muſt be repeated three or four times, becauſe it is this liquor which renders the cotton more or leſs fit for receiving the dye. Each bath is given with the ſame liquor, and ought to continue five or ſix hours. It is to be obſerved that the cotton, after each bath, muſt be dried without being waſhed, as it ought not to be rinſed till after the laſt bath. The cotton is then as white as if it had been bleached in the fields.

It may be ſuppoſed that the dung is of no utility for fixing the colours: but this ſuppoſition would be raſh; for, as M. Felix obſerves, it is well known that this ſubſtance contains a great quantity of volatile alkali in a diſengaged ſtate, which has the property of giving a roſy hue to the red. It is therefore probable that it is to this ingredient that the red dyes of the Levant are indebted for their ſplendour and vivacity. This much, at any rate, is certain, that the Morocco leather of the Levant is prepared with dog's dung; becauſe it has been found that this dung is proper for heightening the colour of the lack.

The proceſs of galling, which follows the bath of dung, is performed by immerſing the cotton in a bath of warm water, in which five occas of pulveriſed gall-nuts have been boiled. This operation renders the cotton more fit for being ſaturated with the colour, and gives to the dye more body and ſtrength. After the galling comes aluming, which is performed twice, with an interval of two days, and which conſiſts in dipping the cotton into a bath of water in which five occas of alum have been infuſed, mixed with five occas of water alkaliſed by a ley of ſoda. The aluming muſt be performed with care, as it is this operation which makes the colouring particles combine beſt with the cotton, and which ſecures them in part from the deſtructive action of the air. When the ſecond aluming is finiſhed, the cotton is wrung; it is then preſſed, and put to ſoak in running water, after being incloſed in a bag of thin cloth.

The workmen then proceed to the dyeing. To compoſe the colours, they put in a kettle five occas of water, and 25 occas of a root which the Greeks call *ali-zari*, or painting colour, and which in Europe is known under the name of *madder*. The madder, after being pulveriſed, is moiſtened with one occa of ox or ſheep's blood. The blood ſtrengthens the colour, and the doſe is increaſed or leſſened according to the ſhade of colour required. An equal heat is maintained below the kettle, but not too violent; and when the liquor ferments, and begins to grow warm, the ſkains are then gradually immerſed before the liquor becomes too hot. They are then tied with packthread to ſmall rods placed croſſwiſe above the kettle for that purpoſe; and when the liquor boils well, and in an uniform manner, the rods from which the ſkains were ſuſpended are removed, and the cotton is ſuffered to fall into the kettle, where it muſt remain till two-thirds of the water is evaporated. When one third only of the liquor remains, the cotton is taken out and waſhed in pure water.

The dye is afterwards brought to perfection by means of a bath alkaliſed with ſoda. This manipulation is the moſt difficult and the moſt delicate of the whole, becauſe it is that which gives the colour its tone. The cotton is thrown into this new bath, and made to boil over a ſteady fire till the colour aſſumes the required tint. The whole art conſiſts in catching the proper degree: a careful workman, therefore, muſt watch with the utmoſt attention for the moment when it is neceſſary to take out the cotton; and he will rather burn his hand than miſs that opportunity. Turkey-Red || Reflector.

It appears that this bath, which the Greeks think of ſo much importance, might be ſupplied by a ley of ſoap; and it is probable that ſaponaceous water would give the colour more brightneſs and purity.

M. Felix ſeems doubtful whether the ali-zari of the Greeks be the ſame plant with the European madder. If it be, its ſuperiority muſt ariſe from the mode in which it is cultivated, and the method employed to dry it. The ali-zari is not collected till the fifth or ſixth year of its growth, when it has acquired its full ſtrength; and as it is the woody part of the roots which affords the greateſt quantity of colouring particles, this muſt give it an obvious ſuperiority over madder, which is collected before it has arrived at maturity. The mode of deſiccation contributes alſo, in the opinion of our author, to improve the quality of the ali-zari. The Levantines dry it in the open air; and this operation is eaſy in a country where great dryneſs prevails in the atmoſphere, while in our damp climates we are obliged to dry the madder by ſtoves. Hence it happens that the ſmoke, which mixes itſelf with the cold air, and penetrates the roots, impregnates them with fuliginous particles, which alter the colouring ſubſtance; an accident which does not take place when the madder is dried without the aſſiſtance of fire.

For the philoſophical principles of theſe proceſſes of dyeing, ſee *Animal and Vegetable Substances* in this *Supplement*.

REDINTEGRATION, is the taking or finding the integral or fluent again from the fluxion. See Fluxions, *Encycl.*

REFLECTOR for a light-house, is compoſed of a number of ſquare plane glaſs mirrors, ſimilar to thoſe with which Archimedes is ſaid to have ſet fire to the Roman fleet at the ſiege of Syracuſe (See Burning, *Encycl.*) Each of theſe mirrors is about an inch ſquare; and they are all diſpoſed cloſe to each other in the concave of a parabolic ſegment, formed of ſtucco or any other proper bed. Stucco has been found to anſwer the purpoſe beſt; and is accordingly employed in all the reflectors of the light-houſes erected by Mr Thomas Smith tinplate worker, Edinburgh, at the expence, and by the authority, of government. This ingenious and modeſt man ſeems to have conceived the idea of illuminating light-houſes by means of lamps and reflectors inſtead of coal-fires, without knowing that ſomething of the ſame kind had been long uſed in France; he has therefore all the merit of an inventor, and what he invented he has carried to a high degree of perfection.

His parabolic moulds are from three to five or ſix feet in diameter; and in the centre or apex of each is placed a long ſhallow lamp of tin-plate, filled with whale oil. In each lamp are ſix cotton wicks, almoſt contiguous to each other, which are ſo diſpoſed as to burn without trimming for about ſix hours. The light of theſe is reflected from each mirror ſpread over the concave ſurface, and is thus multiplied, as it were, by the number of mirrors. The ſtucco moulding is covered on the back with tin plate, from which a tube, immediately over the lamp, proceeds to the roof of the

 light

light room, and serves as a funnel, through which the smoke escapes without sullying the faces of the mirrors. The light-room is a cupola or lantern of from eight to twelve sides, composed entirely of glass, fixed in cast-iron frames or sashes, and roofed with copper. On circular benches passing round the inside of this lantern, at about eighteen inches from the glass frames, are placed the reflectors with their lamps, so as that the concave surfaces of two or three of the reflectors front every point of the compass, and throw a blaze of light in all directions. In the roof immediately over the centre of the room is a hole, through which pass all the funnels already mentioned, and which serves likewise to admit fresh air to the lamps. This light-room is firmly fixed on the top of a round tower so as to be immoveable by the weather; and the number of the reflectors, and the height of the tower, are less or greater according as it is the intention that the light should be seen at a less or a greater distance.

A man judging from mere theory would be very apt to condemn light-houses of this kind; because the firmest building shakes in a violent storm, and because such shaking, he might think, would sometimes throw the whole rays of light into the air, and thus mislead the bewildered seaman. This opinion, we know, was actually entertained of them by one of the profoundest philosophers and most scientific mechanicians of the age. Experience, however, has convinced him, as well as the public at large, that such apprehensions are groundless, and that light-houses with lamps and reflectors are, in every point of view, preferable to those with fires burning in the open air. They are supported at much less expence; their light is more brilliant, and seen at a greater distance, whilst it can never be obscured by

r beaten down on the lee side by a violent gust and what is perhaps of still greater importance, the reflectors with their lamps may be so variously placed, that, as Mr Smith observes, one light-house cannot be mistaken for another. If we add to all this, that the lamps do not stand in need of trimming so often as open fires require fuel, and that the light man is never exposed either to cold or to wet by attending to his duty, we must be convinced that light-houses with reflectors are much less liable to be neglected in stormy weather than those with open fires, and that this circumstance alone would be enough to give the former a preference, almost incalculable, over the latter.

It has been proposed to make the concave surface of the parabola one speculum of metal, instead of covering it over with a multitude of plain glass mirrors; or to diminish the size of each mirror, if they are to be retained in preference to the metallic speculum. To every man who has but dipped into the science of optics, it must be obvious, that either of these alterations would be wrong. The brightest metal does not reflect such a quantity of light as well foliated clear glass; and were the size of the mirrors to be diminished, the number of joinings would be increased, in each of which some light is lost, not merely in the seam, but from its being almost impossible to foliate glass perfectly at its edge.

REFLEXITY, a word employed by Mr Brougham to denote a property of light which causes the different rays to be acted upon by bodies, and to begin to be refracted, reflected, inflected, and deflected, at different distances. This property follows the same law that the other optical properties of light follow: the red ray having most reflexity, and the violet least (See *Philosophical Transactions*, 1797, p. 360.) Mr Brougham has denoted this property by the three words, *refrangity*, *reflexity*, and *flexity*; but as the power is the same, there is no occasion for different names. Some philosophers have refused to admit this as a new property; we have not verified it by experiment.

REFRACTION OF ALTITUDE, is the arc or portion of a vertical circle, by which the altitude of a star is increased by the refraction of light.

Refraction of Ascension and Descension, is an arc of the equator, by which the ascension and descension of a star, whether right or oblique, is increased or diminished by the refraction.

Refraction of Declination, is an arc of a circle of declination, by which the declination of a star is increased or diminished by refraction.

Refraction of Latitude, is an arc of a circle of latitude, by which the latitude of a star is increased or diminished by the refraction.

Refraction of Longitude, is an arc of the ecliptic, by which the longitude of a star is increased or diminished by means of the refraction.

Terrestrial Refraction, is that by which terrestrial objects appear to be raised higher than they really are, in observing their altitudes. The quantity of this refraction is estimated by Dr Maskelyne at one tenth; by Le Gendre at one fourteenth; by De Lambre at one-eleventh; and by others at a twelfth of the distance of the object observed, expressed in degrees of a great circle. But it is obvious that there can be no fixed quantity of this refraction, since it depends upon the state of the atmosphere, which is extremely variable. Hence some very singular effects of it are relat which the following is worthy of notice. It is from the Philosophical Transactions of London, being an extract of a letter, dated Hastings, August 1797.

"On Wednesday, July 26, about five o'clock in the afternoon, while I was sitting in my dining room at this place, which is situated upon the Parade, close to the sea shore, nearly fronting the south, my attention was excited by a number of people running down to the sea-side. Upon enquiring the reason, I was informed that the coast of France was plainly to be distinguished by the naked eye. I immediately went down to the shore, and was surprised to find that, even without the assistance of a telescope, I could very plainly see the cliffs on the opposite coast; which, at the nearest part, are between 40 and 50 miles distant, and are not to be discerned, from that low situation, by the aid of the best glasses. They appeared to be only a few miles off, and seemed to extend for some leagues along the coast. I pursued my walk along the shore eastward, close to the water's edge, conversing with the sailors and fishermen upon the subject. They at first could not be persuaded of the reality of the appearance; but they soon became so thoroughly convinced, by the cliffs gradually appearing more elevated, and approaching nearer, as it were, that they pointed out and named to me the different places they had been accustomed to visit; such as the Bay, the Old Head or Man, the Windmill, &c. at Boulogne; St Vallery, and other places on the coast of Picardy; which they afterwards confirmed when they

Regis || Regulus.

they viewed them through their teleſcopes. Their obſervations were, that the places appeared as near as if they were ſailing, at a ſmall diſtance, into the harbours."

The writer of this extract was W. Latham, Eſq; F. R. S. and A. S. who adds, that the day was extremely hot, that it was high water at Haſtings about two o'clock P. M. and that not a breath of wind was ſtirring the whole day.

REGIS (Peter Sylvain), a French philoſopher, and great propagator of Carteſianiſm, was born in Agenois 1632. He cultivated the languages and philoſophy under the Jeſuits at Cahors, and afterwards divinity in the univerſity of that town, being deſigned for the church. He made ſo uncommon a progreſs, that at the end of four years he was offered a doctor's degree without the uſual charges; but he did not think it became him to accept of it till he had ſtudied alſo in the Sorbonne at Paris He went thither, but was ſoon diſguſted with theology: and as the philoſophy of Des Cartes began at that time to make a noiſe through the lectures of Rohault, he conceived a taſte for it, and gave himſelf up entirely to it. He frequented theſe lectures; and becoming an adept, went to Toulouſe in 1665, and read lectures in it himſelf. Having fine parts, a clear and fluent manner, and a happy way of making himſelf underſtood, he drew all ſorts of people; the magiſtrates, the learned, the eccleſiaſtics, and the very women, who now all affected to abjure the ancient philoſophy. In 1680 he returned to Paris; where the concourſe about him was ſuch, that the ſticklers for Peripateticiſm began to be alarmed. They applied to the archbiſhop of Paris, who thought it expedient, in the name of the king, to put a ſtop to the lectures; which accordingly were diſcontinued for ſeveral months. The whole life of Regis was ſpent in propagating the new philoſophy. In 1690 he publiſhed a formal ſyſtem of it, containing logic, metaphyſics, phyſics, and morals, in 3 vols 4to, and written in French. It was reprinted the year after at Amſterdam, with the addition of a diſcourſe upon ancient and modern philoſophy. He wrote afterwards ſeveral pieces in defence of his ſyſtem, in which he had diſputes with M. Huet, Du Hamel, Malebranche, and others. His works, though abounding with ingenuity and learning, have been diſregarded, in conſequence of the great diſcoveries and advancement in philoſophic knowledge that have been ſince made. He died in 1707. He had been choſen member of the academy of ſciences in 1699*.

* Biog. Dict. new edit.

REGULAR BODY, called alſo *Platonic Body*, is a body or ſolid comprehended by like, equal, and regular plane figures, and whoſe ſolid angles are all equal.

The plane figures by which the ſolid is contained are the faces of the ſolid; and the ſides of the plane figures are the edges, or linear ſides of the ſolid.

There are only five regular ſolids, viz.

The tetrahedron, or regular triangular pyramid, having four triangular faces;

The hexahedron, or cube, having ſix ſquare faces;

The octahedron, having eight triangular faces;

The dodecahedron, having twelve pentagonal faces;

The icoſahedron, having twenty triangular faces.

Beſides theſe five, there can be no other regular bodies in nature. See PLATONIC *Body*, Suppl.

REGULUS, in aſtronomy, a ſtar of the firſt magnitude, in the conſtellation Leo; called alſo, from its ſituation, *Cor Leonis*, or the *Lion's Heart*: by the Arabs, *Allabor*; and by the Chaldeans, *Kalbeleced*, or *Karbeleced*; from an opinion of its influencing the affairs of the heavens.

Reid.

REID (Thomas, D. D.), ſo well known to the public by his moral and metaphyſical writings, was the ſon of the Rev. Lewis Reid, miniſter of the pariſh of Strachan, in the county of Kincardine, North Britain. His mother was the daughter of David Gregory, Eſq; of Kinardie, of whom ſome account has been given in this *Supplement*, and ſiſter to David, James, and Charles Gregories, who were at the ſame time profeſſors of aſtronomy, or mathematics, in the univerſities of Oxford, Edinburgh, and St Andrews.

He was born at the parſonage houſe of Strachan in April 1710, and received the rudiments of his education at the pariſh ſchool of Kincardine-oniel. At that period the parochial ſchools of Scotland were very ſuperior to what they are now; and young men went from them to the univerſity well furniſhed with philological learning. The progreſs of young Reid muſt have been rapid; for he was removed from ſchool to the Mariſchal College, Aberdeen, when not more than twelve years of age; and we have never heard that he was admitted into the univerſity before he wa to profit by the lectures of the profeſſors. On the trary, he ſoon diſplayed the genius of his mother's family, and ſhone conſpicuous among the ſtudents of mathematics in a college where that ſcience has been at all times cultivated with ardour and ſucceſs.

After the uſual courſe of four years employed in the ſtudy of Latin, Greek, Mathematics, and Philoſophy, he probably took his degree of M. A. which at that period, and for a long time ſubſequent to it, univerſal practice in the univerſity of Aberdeen, and then commenced the ſtudy of theology. In due time he was licenſed to preach the goſpel according to the forms of the church of Scotland; but continued to reſide for ſome years in Aberdeen, cultivating his favourite ſcience, mathematics.

The mathematical chair in Mariſchal College was then filled by Mr John Stuart, a man of great eminence in his profeſſion; but who, like many other profound mathematicians, was not happy in his mode of communicating ſcience, at leaſt to the duller part of his pupils. Mr Reid occaſionally read lectures for the profeſſor; and a friend of our's, by no means dull, has often heard to expreſs great ſatisfaction that Mr Stuart was kept a whole winter from the ſchools, when he ſtudent, and that the claſs was taught by Mr Reid. "Had it not been for this circumſtance (ſaid he) I ſhould never have underſtood more of mathematics than the firſt ſix books of Euclid's elements; but Mr Reid had the faculty of making every thing intelligible to the ſtudents which he clearly apprehended himſelf."

He could not, however, ſpend his life in the ſtudy of mathematics, and in reading barren lectures for other men. He had been educated for the church; and it was in the church only that he had the proſpect of gaining a livelihood. He was accordingly preſented, we know not in what year, to the church of *New Machar* in Aberdeenſhire, at a time when the good people of Scotland were very far from being reconciled to the rights of patronage; and the conſequence was, that

that his settlement met with much popular opposition. Even a little riot took place in the church at his ordination, but he soon gained the affections of his flock by his good sense, his acknowledged worth, and his unwearied attention to all their wants, which he was ever ready to relieve to the utmost extent of his abilities. So deeply rooted indeed was their regard for him at last, that, though it is now almost half a century since his relation to the parish of New Machar ceased, his memory continues to be revered in that parish even at the present day; and the following anecdote evinces that it is not revered without reason.

A man who, from being in decent circumstances, and a member of the kirk session (See PRESBYTERIANS, *Encycl*), when Dr Reid was minister, had become, in his old age, poor and infirm, observed to the then minister of the parish, that if he were able to go to Glasgow, and make his case known to his old friend and pastor, he was sure that he would get something done for him. This observation was reported to the Doctor, who instantly recollected the man, though, in all probability, he had not thought of him for thirty years; and he settled upon him an annual pension of ten pounds, which was punctually paid as long as they both lived. The pride of science had not from the mind of this great man eradicated the amiable sympathies of humanity, nor had his philosophic fame made him overlook the unaspiring duties of the Christian pastor.

In the year 1751, about the beginning of the session or annual term, one of the professors of philosophy in King's College, Aberdeen, died; and his death being unexpected, presented to the other members of that learned body some difficulty in carrying on the usual course of education for that year. At this our readers will not be surprised, when they reflect on the mode in which science was taught in that university; for he who could with propriety be placed in the vacant chair, must have been qualified, without much previous preparation, to read lectures on LOGIC, ONTOLOGY, PNEUMATICS, MORALS, POLITICS, MATHEMATICS, and NATURAL PHILOSOPHY (See GERARD, in this *Suppl.*). In such a place as Aberdeen, it is hardly to be supposed that there was a single man unemployed, so completely master of all these branches of science, as to take up the class where it was dropt by the deceased professor, and carry it successfully through that science, whatever it might be, in which, at his death, he chanced to be lecturing. It occurred, however, to the principal, and some of the professors, that the minister of New Machar was fully equal to the task; and the late Dr John Gregory, then professor of medicine, and the Rev. Dr Macleod, the present subprincipal of King's College, were deputed to visit Mr Reid, and request his immediate acceptance of the vacant professorship. He yielded to the request not without some hesitation, and was admitted professor of philosophy on the 22d of November.

He was now in the very situation for which Nature seemed to have intended him. He had not only an opportunity, but it was his duty to cultivate the science to which his attachment was so strong; and the duties of his office made him turn his attention more closely than he had hitherto done to another science, in which he was destined to make a more conspicuous figure than he ever made even in his favourite mathematics.

It was during his professorship in the university of Aberdeen that he wrote his "Essay on Quantity," which was published in the 45th volume of the Philosophical Transactions, and is perhaps the finest specimen of metaphysical mathematics, if we may use such an expression, that is extant in our own or in any other language (See QUANTITY, *Encycl.*). It was during the same period that he published his "Inquiry into the Human Mind on the Principles of Common Sense;" a work of unquestionable merit, which has contributed more than any other work whatever to give a rational turn to metaphysical speculations. It was about this period that the degree of D. D. was conferred upon him by his mother-college.

The well earned fame of Dr Reid attracted the attention of the university of Glasgow to him as the fittest person to succeed the celebrated Dr Adam Smith; and he was admitted professor of moral philosophy in that university on the 11th of June 1764. There his attention was not distracted by a multitude of sciences, which it was his duty to teach; and he had leisure to improve his metaphysical system, though he continued through life to amuse himself occasionally with mathematical speculations.

In the year 1773 appeared, in Lord Kames's "Sketches of the History of Man, a brief Account of Aristotle's Logic; with remarks by Dr Reid." It would seem that he had entered upon this task rather reluctantly, and merely in compliance with the solicitations of his friend, the author of the Sketches. "In attempting (says he) to give some account of the analytics, and of the topics of Aristotle, ingenuity requires me to confess, that though I have often purposed to read the whole with care, and to understand what is intelligible, yet my courage and patience always failed before I had done. Why should I throw away so much time and painful attention upon a thing of so little use? If I had lived in those ages when the knowledge of Aristotle's Organon intitled a man to the highest rank in philosophy, ambition might have induced me to employ upon it some years of painful study; and less, I conceive, would not be sufficient. Such reflections as these always got the better of my resolution, when the first ardour began to cool. All I can say is, that I have read some parts of the different books with care, some slightly, and some perhaps not at all. I have glanced over the whole often; and when any thing attracted my attention, have dipped into it till my appetite was satisfied."

Notwithstanding this modest acknowledgment, we are not sure that any one of Dr Reid's publications does him greater honour than his very perspicuous view of this stupendous system. Having ourselves occasionally looked into the writings of Aristotle, we should not hesitate to say, that it is by much the best analysis of these writings that we have anywhere met with, even though we could not corroborate our own opinion by that of other men much more conversant than we are with the oracular language of the Stagyrite. But when it is known that the late Dr Doig of Stirling, to whom Greek was as familiar as his mother tongue, and an equally learned Doctor of Oxford, who has been reading Aristotle ever since he was fourteen years of age, agreed in opinion, that a more accurate view of his logic could not be given in the same compass than had been

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been given by Dr Reid, we may furely affirm, with fome degree of confidence, that this fmall work adds much to the fame of our celebrated countryman.

Though Dr Reid's health continued good, and his mental faculties unimpaired, till a very fhort time before his death, he ceafed for fome years to read lectures from his profefforial chair, employing that time in preparations for eternity, and in fitting his lectures for the prefs. Thefe were publifhed in two volumes 4to: the the firft in 1785, under the title of "Effays on the Intellectual Powers of Man," dedicated to his friends Dr Gregory and Profeffor Stewart, both of the univerfity of Edinburgh; and the fecond in 1788, under the title of "Effays on the Active Powers of Man," without any dedication or preface. He continued to enjoy the fame acquired by this work, as well as the affection of his friends and the reverence of the public, for eight years, dying at Glafgow in the end of September, or the beginning of October 1796, in the 87th year of his age. He had been married, and he left behind him one daughter.

To do juftice to the biography of fuch a man as this, we fhould here attempt to draw his intellectual character, and to appreciate the merits of his works; but to perform this tafk in a manner at all worthy of him, or we hope of ourfelves, would require more room than our limits permit us to allot to any article of the kind; and our readers will be pleafed to learn, that they may confidently expect an account of his life, with a critique on his works, by a man better qualified to do juftice to both, than the writer of this fhort fketch pretends to be. His works are in the hands of the fpeculative public; and by that public will be duly valued, as long as found fenfe fhall be preferred to unpleafing jargon. How long that may be, God only knows; but if any [illegible] to guard the minds of our youth againft that [illegible] of which the object is to attribute real agency [illegible] fluids, and to reprefent the elective attractions of chemiftry as perfectly fimilar to human volitions, it will be the unbiaffed ftudy of Dr Reid's "Effays on the Intellectual and Active Powers of Man." They will there find metaphyfics divefted of myftery, and the profoundeft fpeculations rendered intelligible by the conftant ufe of words in one determined fenfe. We think, indeed, that in this confifts the Doctor's chief merit; for, except when treating of our notions of power, he feems not to have added much to what certainly *may be* found in the writings of Locke.

Let not our readers fuppofe, that by this obfervation we wifh to detract in the fmalleft degree from our author's fame, or to leffen him by comparifon with the Englifh philofopher. If on mere topics of fpeculative fcience, he appears to us to have thought as Locke thought, it is on the other hand certain, that the greater part of Locke's doctrines may be gleaned from the logical and metaphyfical writings of Bacon, Hobbes, and Des Cartes. Nor need this furprife any one; for he who reflects a moment on the fubject, muft perceive that fuch a coincidence of thought in metaphyfical fcience is among men of eminence almoft inevitable. Of mind and its powers—the fubject of that fcience—we neither know, nor can know any thing, but by patiently attending to the operations of our own minds, when we fee, hear, feel, think, reafon, and will, &c.: and it is obvious, that every man who is capable of fuch patient attention, and does not labour under the bias of fome prejudice, muft view thefe operations in the fame way. The great fuperiority of Dr Reid over his predeceffors, in this department of fcience, appears to have been this, that he apprehended the operations of his own mind with a clearnefs, which gave to his language a precifion and perfpicuity which the language of Locke certainly does not poffefs.

In the Effay on the Human Underftanding, the term *idea* fometimes fignifies a material fubftance, fometimes the qualities of that fubftance, fometimes the conception of thefe qualities, fometimes the power or faculty of the mind by which we conceive a thing, fometimes a perception of fenfe, and fometimes an intellectual notion. Hence the ambiguity of terms which runs thro' the whole of that immortal work, has furnifhed both the author's friends and his enemies with an opportunity of attributing to him pernicious doctrines, which we are perfuaded he did not maintain, and which, we think, a patient analyfis of the effay muft *convince every man* that he did not maintain. From this ambiguity the writings of Dr Reid are perfectly free. His doctrines, whether well or ill-founded, can never be mifunderftood by him who is defirous to underftand them; and he who knows how much perfpicuity of ftyle depends upon accuracy of thinking, will not deem us enemies to his fame for having faid that his chief merit confifts in the precifion of his language.

He has been much cenfured by fome, and much applauded by others, for introducing the phrafe *common fenfe* into fpeculative philofophy, as the proper name of that faculty of the mind by which we apprehend firft truths; but he is on this account entitled neither to praife nor to cenfure. He adopted the phrafe from others; and has proved, by the moft unexceptionable authorities, both ancient and modern, that it may with great propriety be ufed as he has ufed it. Whether the adopting of it into works of fcience was neceffary, is another queftion, on which we have given our opinion elfewhere; it is fufficient in this place to vindicate his ufe of it, efpecially in his latter works, from ambiguity.

Candour obliges us to acknowledge, that he has advanced fome doctrines which we cannot admit as true. Though not in general partial to Locke, he has adopted his notions refpecting our power of abftraction, with hardly any other variation than the fubftituting of the term *conceptions* for Locke's favourite phrafe *ideas*. He has likewife endeavoured to prove, that we may diftinctly conceive what cannot poffibly exift. Thefe miftakes, for fuch they appear to us, we have pointed out elfewhere (See Metaphysics, Part I. Chap. iii. and iv. *Encycl.*); but they are infinitely more than counterbalanced by his clear, accurate, and fatisfactory difquifitions on our notions of active power. Had Dr Reid never written a fentence but the effay which treats of this delicate and important fubject, he would have been entitled to a place in the very firft rank of ufeful metaphyficians; for, previous to the appearance of his works, we had nothing written directly on *power* but contradictory and unintelligible jargon. We recommend the ferious perufal of this effay, the firft in his fecond volume, to fuch of our readers as fancy that they diftinctly conceive the powers of chemical agents, and that intelligence and volition may refult from any mechanical organization,

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organization, or any combination whatever of matter and motion.

REISKE (John James), a most profound scholar and sagacious critic, was born in 1706 at a small town of the duchy of Anhalt. After struggling with some difficulties in his school education, in which, however, he, by perseverance, obtained considerable advantages, he went, in 1733, to Leipsic; where he continued, for the sake of study, five years. Here he accomplished himself in Arabic, and translated and published a book from that language. In order to prosecute his study of Arabic with greater effect, he travelled on foot, and with many difficulties, to Leyden. Here he was employed in arranging the Arabic manuscripts, for which, however, he received a very scanty compensation; and here also he translated from the German and French, into Latin, various essays sent him by Dorville, whom he had visited in his journey, and who afterwards inserted these papers in the *Miscellanea Critica*. Dorville was so well pleased with his skill and diligence, that he employed him in more important concerns. At his desire, Reiske translated the whole of the Chariton from the Greek, and the Geography of Abulfeda from the Arabic, into Latin. At Leyden he continued for the space of eight years; where a storm of jealousy and calumny, excited against him by the younger Burman, finally induced him to change his residence. This was principally owing to the freedom he used with respect to the edition of Petronius, edited by the younger Burman at Leyden; however, before he quitted it, he took the degree of doctor of physic, which was given him in a manner which did him the highest honour. He then visited different parts of Germany, till he at length settled at Leipsic a second time. Here, for twelve years, notwithstanding he was made professor of Arabic, he experienced all the inconveniences of poverty, and was obliged to undergo a great deal of drudgery for booksellers, and the editors of periodical publications, to procure a subsistence; at this period, in particular, the *Acta Eruditorum* were greatly indebted to him. Amidst all these hardships, however, he found opportunity to write, and to publish, his *Animadversiones in Auctores Græcos*, in five volumes; a work of extraordinary learning and merit. In 1758, by the death of Haltausius, he obtained a situation at once honourable and lucrative, which placed him above want, and enabled him to follow his favourite pursuits at ease. He was made rector of the academy at Leipsic, in which office he continued till the time of his death. In 1764, he married Ernestina Christina Muller, a woman of wonderful attainments, whose knowledge was hardly inferior to his own and particularly in Greek literature. She assisted him in all his literary labours, and especially in his immortal work of the "Edition of the Greek Orators." Thus, in the manner most grateful to himself, Reiske consumed the remainder of his life, which continued till 1774, when he died possessed of the highest reputation. The number of works which he superintended and published is very great; but it will be sufficient to name those which are most sought after and esteemed. These are, the "Remarks upon Greek Authors," before mentioned. An "Edition of the Greek Orators," in 12 vols 8vo, which was finished by his widow. "Dionysius Halicarnassensis," in 7 vols. "Plutarch's Works," in 9 vols. "Theocritus, &c. &c." This John James Reiske must not be confounded with *John Reiske*, rector of the college of Wolfenbuttel, who was also a learned man, and published various works*.

REMONSTRANTS, in church history, a title given to the ARMINIANS (See that article, *Encycl.*) by reason of the remonstrance which, in 1610, they made to the States of Holland, against the sentence of the synod of Dort, which condemned them as heretics. Episcopius and Grotius were at the head of the *Remonstrants*, whose principles were first openly patronised in England by Archbishop Laud. In Holland, the patrons of Calvinism presented an address in opposition to the remonstrance of the Arminians, and called it a counter-remonstrance. Hence the Dutch Calvinists were termed *Counter remonstrants*. Much controversy was carried on by these rival sects, which, on the side of the Calvinists, was extremely illiberal.

REMORA, or SUCKING FISH, a species of ECHENEIS (See *Encycl.*). M. Vaillant found, upon different parts of his enormous *ray* (See RAJA in this *Suppl.*) about twenty small sucking fish, or *remoras*, fastened so firmly, that they did not drop off when he was hoisted on board. Some naturalists have said, that the head of the sucking fish is viscous on the lower part, and furnished with rough points similar to the teeth of a file; and, according to them, it is by means of these two qualities, its roughness and viscosity, that it is enabled to adhere to other fish.

"Figure to yourself (says one of them) a row of nineteen sharp-edged and dentated laminæ, placed crosswise, and issuing immediately from the rim of the lower jaw, and you will have a just idea of the part with which the remora makes itself fast."

This description (says Vaillant) is exact as far as relates to the figure and number of the dentated laminæ; but it places them on the lower part of the head, whereas they are, in reality, on the upper. Accordingly, when the remora fixes itself, it is obliged to turn upon its back, with its belly upwards.

If the two white fish, however, that posted themselves on the arms of the ray, and served him as pilots, be of the remora species, as he is inclined to think, the laminæ by which that variety adheres to other fishes must be on the lower part of the body, since the two pilots continued in their natural position, and had no occasion to turn over to fix themselves at their post.

REPETEND, in arithmetic, denotes that part of an infinite decimal fraction, which is continually repeated *ad infinitum*. Thus in the numbers 2·13 13 13 &c. the figures 13 are the repetend, and marked thus $\dot{1}\dot{3}$.

REPUBLICANS, the name given by Vaillant, with some propriety, to a kind of birds which were observed in South Africa, both by him and Paterson, to inhabit apparently the same enormous nest. Cutting one of these nests in pieces with a hatchet, he perceived that the principal and fundamental piece consisted of a mass of strong coarse grass (called by the Hottentots *Boshmen's grass*), without any mixture, but so compact and firmly knit together as to be impenetrable to the rain. This nucleus is the commencement of the structure; and each bird builds and applies to it its particular nest. But these cells are formed only beneath and around the mass; the upper surface remains void, without, however, being useless; for, as it has a projecting

* Dict. new edit.

Republicans, Residual.

jecting rim, and is a little inclined, it serves to let the water run off, and preserves each dwelling from the rain. Figure to yourself a huge irregular mass, the summit forming a kind of roof, and all the other parts of the surface completely covered with cells squeezed one against another, and you will have a tolerably accurate idea of these singular edifices.

Each cell is three or four inches in diameter, which is sufficient for the bird. But as they are all in contact with one another through the greater part of the surface of the mass, they appear to the eye to form but one building, and are distinguishable from each other only by a little external aperture, which serves as an entrance to the nest; and even this is sometimes common to three different nests, one of which is situated at the bottom, and the other two at the sides.

The nest which he examined contained 320 inhabited cells, which, supposing a male and female to each, announce a society of 640 individuals. Such a calculation, however, would not be exact; for whenever our author fired at a flock of these birds, he always killed four times as many females as males. "For the rest (says he), these birds have nothing very remarkable in their plumage. It is an uniform brown grey, diversified by a few black spots on the sides; and a large patch of the same colour on the throat. The male is a little larger than the female; in other respects they exactly resemble each other."

RESIDUAL ANALYSIS, a calculus proposed by the inventor, Mr Landen, as a substitute for the method of fluxions. The object of this substitution was to avoid introducing the idea of motion, and of quantities infinitely or indefinitely small, into mathematical investigation. The residual analysis accordingly proceeds, by taking the difference of the same function of a variable quantity in two different states of that quantity, and expressing the relation of this difference to the difference between the two states of the said variable quantity itself. This relation being first expressed generally, is then considered in the case when the difference of the two states of the variable quantity is = 0, and by that means it is evident, that the same thing is done as when the fluxion of a function of a variable quantity is assigned by the ordinary methods.

The evolution of the functions, considered in this very general view, requires the assistance of a new theorem, discovered by Mr Landen, and remarkable for its simplicity, as well as its great extent. It is, that if x and v are any two variable quantities, $\frac{x^{\frac{m}{n}} - v^{\frac{m}{n}}}{x - v}$

$$: x^{\frac{m}{n}-1} \times \frac{1 + \frac{v}{x} + \frac{v^2}{x^2} + \frac{v^3}{x^3} + \cdots (m)}{1 + \left(\frac{v}{x}\right)^{\frac{m}{n}} + \left(\frac{v}{x}\right)^{\frac{2m}{n}} + \left(\frac{v}{x}\right)^{\frac{3m}{n}} \cdots (n)}$$

where m and n are any integer numbers.

This theorem is the basis of the calculus; and from the expressions $x^{\frac{m}{n}} - v^{\frac{m}{n}}$, and $x - v$ having the form of what algebraists call *residuals*, the ingenious inventor gave to his whole method the name of the *residual analysis*.

Residual ‖ Revivification.

The first account of this method was published by Mr Landen in 1758, under the title of a *Discourse concerning the Residual Analysis*. The first book of the Residual Analysis itself was published in 1764; and contained an explanation of the principles of the new calculus, with its application to several of the most considerable problems belonging to the direct method of fluxions. The second book was intended to give the solution of many of the most difficult problems that belong to the inverse method of fluxions, or to the integral calculus; but it has never been published: a circumstance which every one, who has taken the trouble to study the first part of the work, will very much regret.

If we estimate the value of the residual analysis from the genius, profound knowledge, and extensive views required to the discovery of it, it will rank high among works of invention: but if, on the other hand, we estimate its value by its real practical utility, as an instrument of investigation, we must rate it much lower. When compared with the fluxionary calculus, which it was intended to supersede, its principles, though in appearance more rigorous, are much less easily apprehended, much less luminous, and less direct in their application; and therefore, as a means of extending the bounds of mathematical science, it must ever be regarded as vastly inferior to the latter (A).

RETICULA, or RETICULE, in astronomy, a contrivance for measuring very nicely the quantity of eclipses, &c. This instrument, introduced some years since by the Paris Academy of Sciences, is a little frame, consisting of 13 fine silken threads, parallel to, and equidistant from, each other, placed in the focus of object-glasses of telescopes; that is, in the place where the image of the luminary is painted in its full extent. Consequently the diameter of the sun or moon is thus seen divided into 12 equal parts or digits: so that, to find the quantity of the eclipse, there is nothing to do but to number the parts that are dark, or that are luminous. As a square reticule is only proper for the diameter of the luminary, not for the circumference of it, it is sometimes made circular, by drawing six concentric equidistant circles, which represents the phases of the eclipse perfectly. But it is evident that the reticule, whether square or circular, ought to be perfectly equal to the diameter or circumference of the sun or star, such as it appears in the focus of the glass; otherwise the division cannot be just. Now this is no easy matter to effect, because the apparent diameter of the sun and moon differs in each eclipse; nay, that of the moon differs from itself in the progress of the same eclipse. Another imperfection in the reticule is, that its magnitude is determined by that of the image in the focus; and of consequence it will only fit one certain magnitude. See MICROMETER, *Encycl.*

REVETEMENT, in fortification, a strong wall built on the outside of the rampart and parapet, to support the earth, and prevent its rolling into the ditch.

REVIVIFICATION, in physiology, the recalling to

(A) For this view of the *Residual Analysis*, we are obliged to Mr Playfair professor of Mathematics in the University of Edinburgh.

Revivification, French Revolution, 1795.

to life of animals apparently dead. There are many kinds of insects which may be revivified, after all the powers of animation have been suspended for a considerable time. Common flies, small beetles, spiders, moths, bugs, &c. after being drowned in spirit of wine, and continuing apparently dead for more than a quarter of an hour, have been restored to life merely by being thrown among wood-ashes slightly warm.

While Dr Franklin resided in France, he received from America a quantity of Madeira wine which had been bottled in Virginia. In some of the bottles he found a few dead flies, which he exposed to the warm sun, it being then the month of July; and in less than three hours these apparently dead animals recovered life which had been so long suspended. At first they appeared as if convulsed; they then raised themselves on their legs, washed their eyes with their fore feet, dressed their wings with those behind, and began in a little time to fly about.

But the most extraordinary instance of revivification that we ever heard of, is the following: In the warmer parts of France there is an insect very destructive to rye, which seems to begin its operations at the root of the plant, and gradually to proceed upwards to the ear. If the plant be completely dried while the insect is in the root or stem, the animal is irrecoverably killed; but after it has reached the grain, the case is very different. There have been instances, which are noticed in the Academy of Sciences, of these insects being brought to life in a quarter of an hour, by a little warm water, after the grains, in which they were lodged, had been kept dry for 30 years.

What is the metaphysician to think of these phenomena, or what conclusion is he to draw from them with respect to the mind or sentient principle? If he be a sober man, he will draw no conclusion; and for this very good reason, that of the sentient principle of insects, and indeed of every animal but man, he knows nothing. He is conscious that it is the same individual being, which, in himself, thinks, and wills, and feels; he knows, that part of his thought is not in one place and part of it in another; and therefore he rationally concludes that this thinking being is not matter, whilst experience teaches him that it quits the material system as soon as that system becomes completely unfit to discharge its functions, and that when it has once taken its flight, it cannot be recalled. Experience teaches him, on the other hand, that the sentient principle of these insects does not quit the material system as soon as that system seems unfit for its functions; and hence he ought to infer, that the minds of men and of insects (if we may use such language), though probably both immaterial, are very different substances; and that the bond which unites the material and immaterial parts of an insect, is certainly different from that which unites the mind and body of man. This is the only inference which can be legitimately drawn from these phenomena; and he who makes them the basis of materialism, must have his judgment warped by some passion or prejudice.

216 Narrative continued

REVOLUTION OF FRANCE. We formerly presented to our readers a concise statement of the commencement and progress of this extraordinary event (See REVOLUTION, *Encycl.*). The singularity of its nature, and the important place which it must hereafter occupy in the moral and political history of mankind, require that we should now resume and continue the detail of its wide-wasting career. We left the subject towards the commencement of the year 1795, at the close of that wonderful campaign, during which the armies of the Republic had exerted themselves with such unparalleled success in every direction. On the one side they had crossed the Pyrennees, and shaken the Spanish monarchy to its centre; while on the other they had driven the united forces of Austria, Prussia, and Britain, from the walls of Landrecies across the Rhine, at all points from Hageneau to the sea, and had finally closed their efforts by the conquest of Holland. At that period, though a prolongation of hostilities was threatened, we scarcely expected that Europe was so soon to witness, or we to record, a succession of military enterprises of a still more romantic and extraordinary nature, the scene of which was even to extend into barbarous countries, where the opinions and the quarrels of the European nations had hitherto remained unknown.

217 Diminished energy of the Convention,

The campaign of 1794, however, was not immediately followed by any important military exertions. The British troops were recalled home, Prussia had been gradually withdrawing from the coalition, and the Austrian armies remained upon the defensive. Neither was the French government in a situation which could enable it to renew its enterprises with vigour, or to give much trouble to the allies. The Convention still existed; but it was no longer that terrible assembly which, under Robespierre and his associates, had, in the short period of fifteen months, reduced two thirds of France under its dominion, and sent forth armies which the combined strength of the rest of Europe seemed unable to resist. While its authority remained almost concentrated in one man, and while the fear of foreign invasion, and the new born enthusiasm for freedom, induced the people to submit to every measure of government, however oppressive or arbitrary, the power of the Convention, and the number of its armies, were unbounded. The dreadful price, however, which they had paid for liberty, and the facility with which they saw it might be lost, had now diminished the political zeal of all classes of citizens. The removal of the foreign armies had dispelled the dread of invasion, and the death of Robespierre, by dissolving the unity of its efforts, and suffering it to fall into contending factions, had greatly weakened the authority of the Convention, and diminished its efficiency as a government.

The fall of Robespierre had been accomplished by two separate conspiracies. At the head of one of these were, Barrere, Billaud Varennes, and Collot d'Herbois, who had been members of the Committee of public safety. The other conspiracy consisted of members of the Convention who did not belong to the committees, and had no immediate share in the administration. Among these, Tallien, Bourdon de l'Oise, and Lecointre of Versailles, were conspicuous. After the destruction of their mutual tyrant, a contest for power took place between these parties. The popularity of Robespierre had once been so considerable, and all men had submitted so tamely to his dominion, that both parties accounted it necessary, in their speeches and writings, to justify to the nation the share they had taken in accomplishing his ruin. It was easy to be eloquent upon such a topic; but its discussion naturally operated to the discredit of the members of the committee, and of the

218 And discredit of the Jacobins,

French Revolution, 1795. the more violent Jacobins, who had been the immediate instruments for carrying into effect his sanguinary measures. They nevertheless retained possession, for some time, of a considerable portion of power. The current of public opinion, however, ran so strongly against them, and the restoration to their seats in the Convention of the seventy one imprisoned members of the Girondist party, added so much to the strength of their antagonists, that they gradually lost their influence, and were threatened to be brought to trial for their conduct.

As early as August 1794, Lecointre of Versailles had denounced the members of the old committee of safety; but his accusation at that time produced little effect. Towards the end of that year, however, their approaching fall became evident. On the 26th of December the Convention ordered, on the motion of Clauzel, that the committees should immediately report upon the conduct of the representatives denounced by Lecointre and all France. Accordingly, on the following day, Merlin of Douay reported, in the name of the committees, that there was no cause for inquiry into the conduct of Vouland, Amar, and David; but that there was room for examining the conduct of Barrere, Billaud Varennes, Collot d'Herbois, and Vadier.

219 Whose leaders were accused, In consequence of this report, a committee of twenty-one members was appointed to make the enquiry. On the 2d of March this year (1795), Saladin presented the report of the commission; in which these four deputies were accused of having participated, as members of the governing committee, in the tyranny and atrocious measures of Robespierre. Their trial commenced before the Convention on the 22d of March; but previous to that period, Vadier had made his escape. The others remained, and rested their defence upon this ground, that although members of the committee of safety, they had no power to resist Robespierre, and that they were not more culpable in having acquiesced in his tyranny than the other members of the Convention, who had all been overpowered for the time by the knowledge that instant destruction awaited every man who should dare to oppose his measures. Except in the case of the cruelties committed by Collot d'Herbois at Lyons, this defence was probably by no means destitute of foundation. It had much weight with the nation at large; in whose eyes it tended, not to exculpate the three persons now accused, but to criminate and degrade the character of the whole Convention.

Carnot, Lindet, Cambon, Duhem, and the other members of what was now called the *Jacobin party*, defended their leaders with considerable ability, and with much vehemence. Nor was the party less active without doors than within the hall of the Convention.

220 And defended by an insurrection For some time they had drawn their friends to the capital from all quarters of the country; and in the morning sitting of the first of April, they commenced their operations by an open insurrection. An immense multitude having assembled in the suburbs, proceeded to the hall of the Convention. A real or factitious scarcity existed at the time. Taking advantage of this circumstance, they pretended they were going to petition for bread; and this pretence drew numbers along with them who had no share in their designs.

Boissy d'Anglas, a conspicuous member of the moderate party, was addressing the Convention upon the means of removing the present scarcity when the insurgents arrived, drove the centinels from their posts, and suddenly filled the hall. They tumultuously demanded "Bread, and the Constitution." The Jacobin party supported the insurgents; and one of the multitude, in a vehement harangue, exclaimed, "We are men of the 14th of July, of the 10th of August, and of the 31st of May." He demanded, that the Convention should change its late measures, that the people should no longer be the victims of mercantile rapacity, and that the accused patriots should not be sacrificed to the passions of their antagonists. The Convention ordered the tocsin to be rung, and the people of Paris to be called to arms. General Pichegru was in Paris at the time; and, upon the motion of Barras, he was appointed to the command of the military force.

221 Which is quelled by Pichegru. The citizens of Paris, who remembered with horror the domination of Robespierre and his adherents, and now saw themselves menaced with its return, instantly called each other to arms, and assembled, by six in the evening, for the protection of the Convention, to the amount of 20,000 men. Till that time the assembly had remained under no small disquietude, surrounded by the insurgents, and listening to the addresses of their orators, and the speeches of the Jacobin minority in their favour. The majority was now rescued from this state of constraint; and, on the motion of Dumont, without proceeding farther in the trial, it was decreed that Barrere, Collot d'Herbois, and Billaud Varennes, should immediately be transported to Guiana.

During the following day the insurgents were completely subdued; and the majority of the Convention, taking advantage of their victory, decreed the arrest and confinement, in the castle of Ham in Picardy, of several of the most obnoxious of their antagonists. Among these were Leonard Bourdon, Duhem, Chasles, Choudieu, Ruamps, Foussedoire, Huguet, Bayle, Lecointre, Cambon, Thuriot Maignet, Hentz, Crassons, and Levasseur. 222 Victory of the Convention By departing from the punishment of death, and adopting that of banishment on this occasion, the Convention expected to diminish the ferocity of the contending factions in the state, by rendering the result of a political defeat less fatal than formerly. The design was good; but in attempting to accomplish it, they established the pernicious precedent of inflicting punishment without a trial, which could scarcely fail to prove highly dangerous, if not ultimately fatal, to all their prospects of a free and just government.

223 Proposal for a new constitution. The Convention now followed up its victory with the popular measure of preparing for its own dissolution, by endeavouring to frame a fixed constitution for the Republic. The constitution which had been decreed in 1793, under the auspices of Robespierre, was considered as impracticable, and a committee was appointed to report upon the measures which ought now to be adopted. It consisted of Sieyes, Cambaceres, Merlin of Douay, Thibaudeau, Mathieu, Le Sage of Eure and Loire, and Latouche. On the 19th of April, Cambaceres reported, that it was the opinion of this committee that a commission should be appointed to frame an entirely new constitution. The Convention accordingly appointed the following persons to this important office, Le Sage, Louvet, Boissy d'Anglas, Creuze, Latouche, Bertier, Daunow, Baudin, Durand, Maillane, Languinais, La Reveillere Lepaux, and Thibaudeau. All other citizens of every description were

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at the same time invited to communicate projects upon the subject, and the committee was required to order the best conceived of these to be printed.

The Convention farther gratified the feelings of the great majority of the nation, by bringing to trial Fouquier Jenville the president, and fifteen judges and jurors of the late revolutionary tribunal. They were convicted on the 8th of May, and executed on the following day, amidst the execrations of a multitude of spectators.

224 New insurrection of the Jacobins.

In the mean time, though defeated on the 1st and 2d of April, the Jacobins by no means considered themselves as subdued. On the contrary, they were preparing a new and more extensive insurrection, which should not, like the former, be confined to the capital. They fixed upon the 20th of May as the day of revolt. Thuriot, and Robespierre's financier Cambon, had found means to escape from the castle of Ham in Picardy, and to come to Paris. They concealed themselves in the suburb St Antoine, and from thence gave counsel to their party, and urged them to action. The scarcity of bread had increased, and advantage was again taken of this circumstance. For some days the walls were covered in various places of Paris with printed accusations against the Convention of withholding bread from the people, and attempts were made to excite the troops in the city to join the disaffected party. On the evening of the 19th, a paper was openly distributed in the different sections, explaining the object of the approaching insurrection. It declared insurrection to be the most sacred duty of the people, and called upon the citizens of Paris to proceed in a mass to the Convention, to demand from it bread and the establishment of Robespierre's constitution, together with a new election of national representatives.

On the morning of the 20th, the tocsin was rung, and drums beat to arms in the suburb St Antoine, which had always been the quarter of the city in which the Jacobins possessed the greatest strength. Upon this alarm the Convention assembled; but although the intended insurrection was no secret, and though the committee of public and general safety now made a report, in which they confessed their previous knowledge of it, yet it does not appear that any vigorous measures of precaution had been taken; for it was only at the instant when the insurgents were actually approaching, that General Hoche was appointed to command the armed force, and was sent forth to assemble the military and the citizens for the defence of the Convention. In the mean time, the multitude surrounded the hall. They soon overpowered the guards, and burst into the midst of the assembly. In all the turbulent days of the revolution, the women of Paris have never failed to act a conspicuous part. On this occasion they greatly augmented the crowd by their numbers, and the tumult by their cries of "Bread, and the constitution of 1793," which was the rallying exclamation of the party. After some fruitless efforts to restore tranquillity, Vernier the president, an old man, resigned the chair to Boissy D'Anglas, who remained in it with much firmness during the day. The whole strength of the insurgents had not arrived at once; for the first party that approached, although they forced their way into the hall, were soon repulsed by the aid of a few soldiers and citizens, who came to the assistance of the Convention. A short interval of tranquillity was thus obtained; but the attack was speedily renewed with double fury by armed men, who subdued all opposition, and entered the hall with cockades, on which was written the inscription, "Bread, and the constitution of 1793." While things were in this state, a citizen of the party of the Convention rashly tore off the hat of one of the insurgents, and was immediately assaulted with swords by the multitude. He fled towards the president's chair, and was killed at the side of it by a musket shot. Ferand, one of the members, having attempted to rescue him, was also attacked. He escaped into one of the passages, where he was also killed, and his head was brought into the Convention upon a pike. The greater number of the members now gradually departed, and left the hall in possession of the insurgents, who acted with some regularity, and proposed a variety of laws favourable to their party, which were instantly decreed. Duroi, Duquesnoi, Bourbotte, and Goujon, were the members who stood most openly forward on this occasion, and appeared as chiefs of the insurrection. But their triumph only lasted a few hours. Towards the evening a large body of citizens joined the military, and marched to the aid of the Convention. Having overcome the insurgents, they entered the hall in great force, and restored the powers of the majority. The decrees that had been forced upon them were repealed as speedily as they had been enacted, and the deputies who had proposed or supported them were arrested.

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225 Who murder some of the Convention, and drive it from the hall.

The citizens of Paris, and even the members of the Convention, appear now to have fancied their victory complete; for they adopted no adequate measures to prevent a new disturbance. But the Jacobins did not so easily give up their own cause. On the following day they once more assembled in the suburbs, and in the afternoon they returned to the attack. They took possession of the Carousal without opposition, and pointed some pieces of cannon against the hall of the Convention. This assembly was now unprotected, and attempted not to subdue, but to flatter, the insurgents. A deputation of the members was sent forth to fraternise with them, and to carry forth two decrees passed at that instant, which ordained that bread should abound; and that Robespierre's constitution of 1793 should immediately be put in force. The insurgents, in return, sent a deputation to the Convention, to express their satisfaction with the decrees, to demand the release of the imprisoned patriots, and the punishment of those who preferred money to assignats. The Convention pretended to agree to all their demands, and the president was ordered to give to the deputation the fraternal embrace.

226 Meanness of the Convention.

The 22d, which was the third day of the insurrection, appears to have been passed by both parties in a strange degree of inaction. The Convention proceeded in its ordinary business; and the Jacobins, at their head quarters in the suburb St Antoine, were occupied in consultations and preparations for new movements. But on the following day the citizens assembled at their sections, and hastened from thence to the Thuilleries to defend the Convention. Considerable bodies of the military were also collected, and the assembly at last resolved to act upon the offensive. A decree was passed, declaring, that if the suburb St Antoine did not instantly surrender its arms and cannon, together with the

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the murderer of Ferand, it should be considered as in a state of rebellion. The conventional generals were at the same time ordered to reduce it by force. The insurgents now found themselves unequal to the contest,

227 Its victory over the Jacobins.

and were compelled to surrender without conditions by the inhabitants of the suburb, who dreaded the destruction of their property by military operations. Several soldiers being found among the prisoners, were put to death; and six members of the Convention were tried and condemned on this occasion by a military commission. Three of these perished by self slaughter, and three were executed. The majority of the Convention, elated by their victory, ordered back Collot D'Herbois, Billaud Varennes, and Barrere to take their trial; but the two former had sailed before the arrival of the courier. Barrere only remained, and he was brought back and imprisoned.

In the mean time, the Jacobins in the south were not less active than their brethren at Paris On the 20th of May they formed a vigorous insurrection at Toulon They seized the gates, and mounted them with cannon; they liberated such of their associates as had been imprisoned, and detained the fleet which was about to sail. Having begun their operations in this successful manner, they marched from Toulon towards Marseilles. Their force amounted to three thousand men and twelve pieces of cannon. They were encountered on their way, however, and defeated by Generals Charton and Pactod. Three hundred of them were carried prisoners to Marseilles, and Toulon was speedily retaken.

The party of the *Mountain*, as it had been called, or of the violent Jacobins, who wished to revive the reign of terror and the measures of Robespierre, was now reduced very low both in the Convention and out of it. Those who adhered to it were even in many places, and more especially in the south, exposed to very violent persecution. Associations were formed, called Companies of *Jesus* and of the *Sun*, for the purpose of avenging the crimes committed by them during the period of their power. At Lyons several of them were massacred in prison, and many of them in all places perished by assassination. On considering the merciless character of the government of Robespierre and his associates, and the persecution which was suffered under it, not merely by the nobles and the rich, but by every man who was distinguished by integrity, talents, or literature, it may appear surprising that it should have obtained admirers, or that any number of individuals should have been found willing to hazard their lives to procure its restoration. Accordingly, from the period of the fall of its leader, the party had gradually been forsaken by its adherents; and the more closely its conduct was considered, it lost ground the more rapidly in the estimation of the public. After the unsuccessful insurrections of the 20th of May, it was treated with the utmost contempt, and its unpopularity was extreme. Still, however, a party remained. It was small, indeed, but its members compensated the inferiority of

228 Who still retain their spirit;

their numbers by superior enterprise and activity. They consisted of outrageous republicans, whose heated imaginations beheld royalty and aristocracy in every proposal for sober and regular government. In the conduct of Robespierre, they remembered only the energy of his measures, by which France was enabled to triumph over the combined efforts of the kings of Europe; and overlooked the atrocities by which he had brought disgrace upon their cause, and rendered his party odious to their own countrymen, as well as to the neighbouring nations. Amidst this universal odium, however, the Jacobins did not despair of rising once more into power; and it is not a little singular, that we must date the revival of their strength from the period of the unsuccessful insurrections which we have just recorded, and which seemed to have extinguished their hopes for ever.

The unpopularity under which the Jacobins laboured soon began to affect the Convention itself. The tame submission of that body to the government of Robespierre was now remembered. It was recollected, that the majority of its members had been the instruments of his power, and had applauded, or at least acquiesced in his crimes. As the press was now free, and the reins of government unsteadily held, their conduct was represented to the public in the most odious colours. A celebrated song, *Le Reveil du Peuple*, became extremely popular, as the means of marking dislike both to the Convention and to the Jacobins; and their conduct was canvassed with the utmost bitterness in a great variety of publications, but more especially in a journal that at this time attracted much notice and which was conducted by Freron, who had himself been a Jacobin, but had now abandoned his party.

229. And terrify the Convention.

In this state of things, the majority of the Convention speedily began to repent of their late victory over the Jacobins. In the first efforts of their zeal, they had taken measures for the immediate formation and establishment of a settled constitution to supersede their own authority; but they now regretted their rashness, when they perceived, from the temper the nation was in, that the men, the most avowedly hostile to their character and measures, would without doubt be elected as their successors. They, and their friends, had arisen to great distinction and wealth under the revolutionary government; and they now began to dread, not only the loss of power, but also a severe investigation of their conduct. These considerations soon produced their natural effects. The decrees for forming and putting in force the constitution could not decently be recalled; but the majority of the Convention set about devising means for rendering them of little importance, so far as they themselves were concerned.

230 New constitution, consisting of

On the 23d of June, Boissy D'Anglas presented the report of the committee that had been appointed to prepare the plan of a constitution. It began, like the former constitutions, with a declaration of the rights of man; and in addition to this, consisted of fourteen chapters, upon the following subjects:—The extent of the territorial possessions of the Republic, the political state of citizens, the primary assemblies, the electoral assemblies, the legislature, the executive power, the municipal bodies, the judicial authority, the public force, public instruction, the finances, foreign treaties, the mode of revising the constitution, and, lastly, an enactment, that no rank or superiority should exist among citizens, excepting what might arise from the exercise of public functions.

The primary assemblies were to possess the right of electing the members of the electoral assemblies, and also the justices of the peace. The electoral assemblies were to nominate the judges and the legislators of the state.

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ſtate. The legiſlature was divided into two aſſemblies; the one of which conſiſted of 250 members, and was called the *Council of the Ancients*, as none but married men and widowers above 40 years of age could be members of it. The other aſſembly or council conſiſted of 500 members, and poſſeſſed the excluſive privilege of propoſing the laws; the Council of Ancients being only intitled to reject or approve, without power to alter the decrees preſented to it. To this rule there was one exception, which was afterwards employed as the means of overturning the whole fabric of the conſtitution; the Council of the Ancients might decree the removal of the legiſlature from its ordinary place of ſitting. To this decree the approbation of the Council of Five Hundred was not neceſſary; and when once enacted, it could not be reconſidered even by the Council of Ancients itſelf. One-third of the members of the two Councils was to be elected annually. A member might be once re-elected, but he could not be elected a third time till an interval of two years had elapſed.

231 Two Councils and an

232 Executive Directory.

The executive power was intruſted to five perſons of forty years of age at leaſt, to be ſtyled the *Executive Directory*. Its members were elected by the two Councils; the Council of Five Hundred electing ten times the number of candidates that might be neceſſary to fill up the vacancies, and the Council of Two Hundred and Fifty nominating the directors from this liſt of candidates. One member of the Directory was to go out annually; ſo that the whole might be changed every five years. The Executive Directory had no vote in the enactment of laws; but it ſuperintended their execution, regulated the coining of money, and diſpoſed of the armed force. Foreign treaties made by it were not binding till ratified by the legiſlative body, nor could it make war without the authority of a decree of the two aſſemblies. The public functionaries were to receive ſalaries, and to appear dreſſed in an appropriated habit.

Each article of this conſtitution was ſeparately diſcuſſed; and on the 23d of Auguſt the whole was declared to be complete, and ordained to be tranſmitted to the primary aſſemblies for their approbation. Previous to this reſolution, however (that is, on the 22d of the ſame month), the majority of the Convention had brought forward the grand meaſure by which they meant to provide for their own ſafety, and the ſafety of their friends and adherents, againſt the change which the public opinion had undergone concerning them. They decreed, that at the approaching general election, the electoral bodies ſhould be bound to chooſe *two-thirds* of the new legiſlature from among the members of the preſent convention; and they afterwards decreed, that, in default of the election of two thirds of the Convention, the Convention ſhould fill up the vacancies themſelves.

233 The Convention fetters the freedom of election.

Theſe decrees were tranſmitted, along with the Conſtitution, to the primary aſſemblies, to be accepted or rejected by them. Many of the primary aſſemblies underſtood, that they could not accept of the conſtitution without accepting along with it the law for the re-election of the *two-thirds*. The point had, in all probability, been purpoſely left under a certain degree of ambiguity; and as the people were now weary of this Convention, they acquieſced in any conditions that gave them the proſpect of one day getting quit of it. But at Paris, and in the neighbouring departments, where the ſubject was more accurately inveſtigated, the public diſapprobation of the Convention diſplayed itſelf with great vehemence.

234 Conſequences of this conduct.

There was indeed ſomething extremely aukward in the decree about the re-election of two thirds of the Convention. That body might, if neceſſary, have continued its own exiſtence for ſome time longer, or it might have diſmiſſed one third of its number by ballot or otherwiſe, and allowed a new election only to that extent; but a compulſory election was an abſurdity ſo new, and ſo obvious, that it gave their antagoniſts every advantage againſt them. Accordingly, at the meetings of the ſections of Paris, the laws for the re-election were rejected with contempt, and their abſurdity demonſtrated with much acrimony. In conſequence of the debates which took place at theſe meetings, the minds of men were gradually inflamed, and it became obvious that a political convulſion approached. On the one ſide, the Convention took care to publiſh daily the approbation of the decrees, along with the conſtitution, by the majority of the primary aſſemblies, by moſt of which the two had been confounded and accepted in the groſs. Its committees alſo called in the aid of the troops of the line for its protection. On the other hand, the language of the ſections became every day more violent. The whole Convention was repreſented as a band of tyrants and of murderers, the aſſociates of all the cruelty of Robeſp[illegible] Mountain party. It was even propoſe[illegible] trial every individual member of the aſſe[illegible] new revolutionary tribunal, and to puniſh him according to his demerits.

For ſome time much anxiety prevailed on both ſides. Numerous deputations were repeatedly ſent from the ſections to the Convention, to remonſtrate againſt the obnoxious decrees. But the eagerneſs with which theſe remonſtrances were made, ſerved only to convince more ſtrongly the members of the Convention of the danger to themſelves as individuals which would attend a reſignation of their power, and confirmed the reſolution they had taken to retain it. The deputies of the ſections having obtained inſpection of the records of the convention, aſſerted, that the national majority, if rightly numbered, had rejected the decrees, as every aſſembly that voted in oppoſition to them was only numbered as one vote, however numerous its members might be; which enabled the primary aſſemblies of remote diſtricts to outvote the more populous ſections of Paris and other great towns. Whereas it was ſaid, that if the individual voters were counted, it would be found that the decrees were diſapproved of by a conſiderable majority. All this was diſregarded by the Convention, and the ſections prepared to decide the diſpute by arms. The firſt ſtep taken by them, however, was ill concerted. A notion was propagated, that as ſoon as the primary aſſemblies or ſections had choſen the electors who were to chooſe the members of the new legiſlature, the national ſovereignty became veſted in theſe electors, and that they had a right to aſſume the government in their various diſtricts. Accordingly, about 100 of the electors of Paris aſſembled in the hall of the French theatre in the ſuburb St Germain, previous to the day of meeting appointed by the Convention. Having choſen

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De Nivernois (formerly the Duke de Nivernois) their preſident, they began their debates. The Convention was alarmed, and inſtantly ſent a body of the military to diſmiſs the meeting as illegal. This was eaſily accompliſhed, as the citizens had not been unanimous with regard to it, and no meaſures were taken for its protection.

Notwithſtanding this firſt advantage on the ſide of the Convention, the ſections regarded its power with contempt, and imagined themſelves ſecure of ultimate ſucceſs. In every political conteſt that had hitherto occurred ſince the commencement of the revolution, the immenſe population of the capital had given a deciſive ſuperiority to the faction whoſe ſide it eſpouſed. The citizens alſo regarded with indifference the armed force with which the Convention had ſurrounded itſelf, from a notion, which they fondly entertained, that the military would in no caſe be brought to act againſt the people. It would appear that the Convention itſelf entertained ſome jealouſy upon this head, and did not account itſelf entirely ſafe under the protection of the ſoldiers. On this occaſion, therefore, it had recourſe to a new ally, and beſought the aid of thoſe very Jacobins whom it had almoſt cruſhed on the 24th of May. The members of the Convention were odious to the ſections of Paris, on account of their participation in the revolutionary crimes and meaſures of Robeſpierre; but this very circumſtance endeared them to the Jacobins, whoſe character it was to imagine that they had never enough of war abroad or of revolution at home. It was eaſy therefore to bring about a reconciliation between the Convention and theſe men. Several hundreds of them were diſmiſſed from the priſons, where they had been confined ſince the two laſt inſurrections, and they were now put in requiſition to defend the legiſlative body.

235 The Convention courts the Jacobins.

When the ſections of Paris beheld the Convention ſurrounded by thoſe Jacobins who had been the unrelenting agents of the government of Robeſpierre, and who were now denominated *terroriſts* and men of blood, their ardour for action became unbounded. They aſſembled in arms at their different ſections on the 12th Vendemaire (October 4th); but they do not ſeem to have acted with much concert, or upon any well digeſted plan of operations. The general deſign of their leaders was to ſeize the members of the Convention, and impriſon them in the church of the Quatre Nations till they could be brought to trial. As this would occaſion a vacancy or interregnum in the government, it was reſolved that all affairs ſhould be conducted by committees of the ſections, till a new legiſlature could be elected. General Miranda, a Spaniard, a native of the Carraccas in South America, who had ſerved in the republican armies, was to be appointed to the chief command of the armed force after the overthrow of the Convention. This man, in his eagerneſs for preferment, had alternately courted all parties, and he now ſeems to have joined the Pariſians upon the ſuppoſition of their being the ſtrongeſt. As he entertained ſome doubts of their ſucceſs, however, he adopted the crooked and timid policy of avoiding the ſtorm by retiring from the city till the combat ſhould be finiſhed, reſolving to return immediately on its concluſion to ſhare the rewards and the triumph of victory.

The Convention, in the mean time, reſolved to ſtrike the firſt blow. For this purpoſe they ſent General Menou to the ſection of Le Pelletier to diſperſe the citizens, whoſe greateſt force was aſſembled there. But this officer, diſliking the ſervice which he was employed to perform, inſtead of proceeding to action, began to negociate with the leaders of the ſections, and ſpent the evening of this day in fruitleſs conferences. The ſections on their ſide appointed General Danican, who had diſtinguiſhed himſelf in the war againſt the Royaliſts in La Vendee to act as their military leader. It would appear, however, that this officer, from the moment that he aſſumed the command, began to deſpair of the cauſe of the ſections. He found them totally deſtitute of cannon, whereas the Convention was ſurrounded by regular troops and a numerous artillery. This inequality in point of weapons appears to have been conſidered by him as a ſufficient reaſon for avoiding an engagement. Occupied in viſiting and arranging the different poſts, he was unacquainted with the diſaffection of the conventional generals. He therefore thought he had done much when he had prevented bloodſhed for another day, and thus the favourable moment for attack was loſt. Whether the ſections would have been ſucceſsful had they been inſtantly led to battle on this important occaſion, cannot now be known. Though the ſuperior officers of the Convention were unfaithful, yet the ſubalterns and the troops in general might have ſtood firm, confirmed as they were by the perſuaſion of their Jacobin auxiliaries. Even in this caſe, however, the fate of a battle might have at leaſt been doubtful. The battalions of Paris were very numerous, their contempt of danger was great, and their ardour unbounded. The mere poſſeſſion of cannon might not in a conteſt againſt ſuch men have afforded ſecurity to the Convention. But the firſt moments of popular enthuſiaſm were ſuffered to paſs away, and that diſtruſt and diſſenſion, which delay never fails to introduce among great and irregular aſſemblages of men, ſoon began to render the conduct of the ſections undecided and weak.

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The conventional committees, during the night of the 12th Vendemaire (October 4th), diſmiſſed Generals Menou, Raffet, and ſome others, from their ſtations, and gave the command of the troops to Barras. He immediately collected around him a variety of able officers, among whom we find the names of Generals Brune and Bonaparte. With their aſſiſtance he began to provide for a moſt vigorous defence. Troops with cannon were ſtationed in all the avenues leading to the Thuilleries. In caſe any of theſe poſts ſhould be forced, maſked batteries were planted in more retired ſituations. Nor was this all; meaſures were taken for conveying the public magazines of proviſions and military ſtores to St Cloud, whither the Convention prepared to retreat if they ſhould ſuffer a defeat at Paris.

On the 13th Vendemaire (October 5th) from which the inſurrection was afterwards named, both parties remained for many hours upon the defenſive. At laſt, about three o'clock in the afternoon, General Danican made advances to an accommodation by a letter to the committee of public ſafety; in which he ſtated, that the only cauſe on account of which the citizens had taken arms was the dread of a maſſacre being intended by the armed terroriſts who ſurrounded the Convention, and that if theſe men were removed, tranquillity would immediately be re-eſtabliſhed. A civil meſſage was re-

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turned; but the Jacobin party in the Convention, being now more confident of victory, and wishing to strengthen themselves by the defeat and punishment of their antagonists, it was resolved that the dispute should be decided by arms. It is not correctly known how the contest commenced, but the armed Jacobins are most generally understood to have begun the attack. The citizens on the southern side of the river attempted to reach the Convention by the Quay de Voltaire, but were speedily repulsed by the conventional cannon; but on the northern side of the river, near the Convention, the combat was extremely obstinate. The cannon were repeatedly seized by the citizens, and repeatedly retaken by the troops and the armed Jacobins. It was not till after a contest of four hours that the sections were repulsed and driven to the post of St Roch. This post was also taken after great slaughter, and the sections were driven to their head quarters at the section of Le Pelletier. After a short interval they were pursued thither by the troops of the Convention, who by midnight were masters of the whole city.

236 Subdues the citizens of Paris.

This insurrection was ascribed by the victorious party to the exertions of the Royalists. It is no doubt true, that by this time Royalty was become less unpopular even among the rabble of France than the extreme of Republicanism, as it had appeared in the conduct of the Mountain party. It is also probable, that the Royalists mingled in a contest that had the overthrow of the present Convention for its object; but the insurgents in general seem neither to have avowed nor entertained any farther view than the disarming of the Jacobins, and the obtaining an immediate election of new representatives. The failure of the attempt had the effect of placing the Mountain party once more at the head of the state. This party at first thought of adjourning the new constitution, and of renewing all the terrors of the revolutionary government. This project, however, was opposed in the Convention with so much vehemence and ability by Thibaudeau, that it was renounced. Indeed it was become unnecessary to the safety or ascendency of the men who proposed it, as the decrees for the re-election of two-thirds of the Convention enabled them to retain the full possession of their power. A few members of the moderate party, such as Boissy D'Anglas, Lanjuinais, and Le Sage, were elected by almost every place in France, though they could only sit for one place. Hence the Convention itself had the re-election of nearly two-thirds of its own members; and the Mountain party, which now commanded the majority, was thus enabled to fill the new legislature with its own leaders.

237 Mountain party, or the most violent Jacobins, again at the head of the state.

On the 27th of October the Convention terminated its sittings, and was succeeded by the new legislature as appointed by the Constitution. By its last decrees, a general amnesty was granted for all revolutionary crimes and proceedings. From this amnesty, however, were excepted the emigrants, the transported priests, and all persons concerned in the last insurrection; so that in fact it was merely a pardon granted by the Mountain party to its own friends for all the excesses they had committed. The members of the Convention, who had been imprisoned in the castle of Ham since the Jacobin insurrection in May, were now set at liberty. The members of the revolutionary committees, and other agents of Robespierre in Paris and the departments, were all dismissed from their prisons, and advanced to the most important offices under the new government.

238 First sitting of the new legislature.

As soon as the new legislature had divided itself into two councils, it proceeded to the election of an Executive Directory. Here the genius of the French nation for intrigue instantly displayed itself. The Council of Five Hundred was bound to present to the Council of Two Hundred and Fifty a list of ten times the number of candidates necessary for the office. It fulfilled this duty in the following manner. The majority of the Council of Five Hundred made out a list, consisting of the five following persons, upon whom they wished the election ultimately to fall: Sieyes, Barras, Rewbell, La Reveillere Lepaux, and Letourneur de la Manche. To complete the list, they added the names of 45 obscure persons, country justices, farmers, and even peasants. Thus there was nothing left to the Council of Ancients but the mere form of an election; and from the want of other qualified candidates, they were under the necessity of nominating to the office of directors the five persons at the head of the list presented by the Council of Five Hundred. The crafty Sieyes, however, who had been the adviser of all parties, but the [illegible] of none, did not yet think fit to venture [illegible] possession of power. He had disappro[illegible] the constitution which was now put in force [illegible] his own in opposition to it [illegible] by the Convention. [illegible] upon which [illegible] power [illegible] from their [illegible] being assigned, any of the public [illegible] they might appoint [illegible] having refused to accept [illegible] was elected in his stead. [illegible] the Council of Ancients was treated with [illegible] little more decency than formerly [illegible] of Cambaceres, a man of considerable [illegible] along with that of Carnot [illegible] by the Council of Five Hundred [illegible] little [illegible] the members of the Directory, with the exception of Reveillere Lepaux, had always belonged to the Mountain or most violent Jacobin party. As they now owed their power to that party, they employed its members in almost every official department. The goverment was therefore necessarily unpopular. Things might have been gradually altered, indeed, by successive elections, which would in time bring other men into power: But, by the forms of the constitution, the executive power was more permanent than the legislative body, without possessing any influence over it. Hence it was to be feared that a contest for power might speedily occur between a directory nominated by the Jacobin party and the new legislators appointed by the people, in which the Constitution might suffer shipwreck; an event which actually occurred.

239 The Council of Five Hundred outwits the Council of Ancients.

While the possession of power continued to fluctuate in the manner we have already stated, between the Moderate and the Jacobin or Mountain parties, the armies of the state were suffered to languish; but upon the credit

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credit of its former military success, the Republic was treated with respect by some of the neighbouring powers. On the 10th of April, a treaty of peace with Prussia, which had been negociated by the committees through the medium of Barthelemi the French resident at Basle, was presented to the Convention for ratification. By this treaty, it was stipulated, that the French troops should immediately evacuate the Prussian territory on the right bank of the Rhine, but should retain the territory belonging to that power on the left bank till a general peace. Prisoners of war were to be mutually restored, and the commerce of the two countries was to be placed on its ancient footing. Measures were also to be taken to remove the theatre of war from the north of Germany by treaties between France and those princes for whom the king of Prussia might interpose.

241 Treatment of the Revolution by foreign powers.

During the same month of April, the French Republic was acknowledged by the king of Sweden; and Baron Stael his ambassador was received at Paris with great solemnity. In the month of May a second treaty with Prussia was concluded. It chiefly regarded the line of neutrality. It is worthy of remark, that these [illegible] contained secret articles [illegible] committee. By [illegible] the Convention [illegible] [illegible] the example of Sweden [illegible] Republic. A [illegible] concluded at Basle [illegible] [illegible] territory of that country [illegible] She received [illegible] of the island of St Domingo [illegible] was included in this treaty [illegible] of the king of Spain [illegible] and the Italian [illegible] the Dauphin [illegible] XVI. died in the prison [illegible] been confined, along with [illegible] of his father, mother, and [illegible] was probably produced by disease [illegible] confinement, if not by [illegible] excited in the French nation such a degree of in[illegible] favour of his family, that the Convention found [illegible] to liberate his sister from imprisonment. The committee of public safety proposed to the Emperor to exchange this princess for the members of the Convention whom Dumourier had delivered up to Austria, along with two ambassadors, Semonville and Maret, who had been seized on their way to Turkey. This proposal was accepted, and the exchange took place at Basle in Switzerland.

243 Naval superiority of Britain.

On the side of Britain the war maintained its former character. The British retained their superiority by sea, and were unfortunate in their efforts on the continent. On the 14th of March the British fleet in the Mediterranean, under Admiral Hotham, engaged the French fleet, and took two sail of the line, the Ca-Ira and the Censeur; but as the French fleet, four days before the engagement, had captured the Berwick, a British ship of the line, when detached from the fleet, and as the Illustrious, another British ship of the line, was so severely injured in the action that she run ashore and was lost at Avenza, the substantial loss on both sides was nearly equal. On the 23d of June another British fleet under Lord Bridport attacked the French off Port L'Orient, and took three ships of the line, the rest of the fleet escaping into that port.

This evident superiority of the British fleet in every contest, induced the government to take advantage of the command which it had of the sea, to give assistance to the French Royalists in the western departments. These Royalists, hitherto unassisted by foreign powers, had, by repeated defeats, been reduced very low. The Convention had at last offered them a treaty, which was accepted and signed at Nantes on the 3d of March, on the one side by deputies from the Convention, and on the other by Charette, Sapineau, and other chiefs of the insurgents of La Vendée, and by Cormartin, as representing the party called *Chouans* or Night Owls. Stofflet, another chief, held out for some weeks longer; but at last, on the 20th of April, he too was under the necessity of submitting by treaty to the Republic.

244 Expedition to Quiberon Bay.

In a short time, however, the hopes of the Royalists were revived by the countenance of the British government, and these treaties were ill observed. In the beginning of June the British expedition was ready to sail for the French coast. The troops to be employed consisted of emigrants in the pay of Great Britain, and many of them had been prisoners of war, who now agreed to join the royal cause. The command during the voyage, and the selection of the place of landing, were intrusted to the Count D'Hervilly. The command on shore was given to Puisaye, who had been employed under the Girondists in the military service of the Republic, but had now become a royalist. The Count de Sombreuil was afterwards sent to join them with a small reinforcement.

On the 25th of June the expedition arrived in the Bay of Quiberon, and on the 27th 2500 emigrants made good their landing, after dispersing a small party of republican troops. The emigrant army soon after distributed itself into cantonments along the shore, and gave arms to the inhabitants of the country, who appeared to receive them with joy. It was soon found, however, that the Chouans, though well qualified for a desultory warfare, could not be of much use to regular troops. They had little subordination. They were easily dispersed, and never fought unless every advantage was on their side. When it was found that their unsteady aid could not be depended on, a resolution was taken to withdraw the emigrant army within the peninsula of Quiberon. The fort of that name was taken on the 3d of July. Its garrison consisted of five or six hundred men, and it was now occupied by the emigrants. A republican army, in the mean time, under General Hoche, advanced, and attacked all the posts that had been left without the peninsula. These were speedily taken. The emigrants and Chouans escaped into the boats of the British fleet, or fled under the cannon of the fort of Quiberon. The republicans then began to construct formidable works on the heights of St Barbe, at the entrance of the peninsula. To prevent their operations, a sally was made from the fort on the 7th of July; but without success. On the 15th, another sally was attempted in greater force. The whole

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whole troops in the peninsula amounted to about 12,000, including Chouans. Out of these a detachment of 5000 was sent to attack the heights of St Barbe. The republicans were entrenched in three camps. The two first of these were easily taken, and the detachment pressed eagerly forward to attack the third. But here a masked battery opened upon them with grape shot. A dreadful carnage ensued; and very few of the detachment could have escaped, had not the fire of the British ships soon compelled the republicans to desist from the pursuit.

245
Its failure.

It now became obvious that the expedition must ultimately fail. Desertion became extremely common among the emigrants. Those men in particular who had been prisoners of war, and received their liberty on condition of joining the expedition, seized every opportunity of going over to their countrymen; and a correspondence seems even to have been established between the republicans and the discontented troops in the fort of Quiberon. On the evening of the 20th of July, the weather was extremely tempestuous, which produced a fatal security in the emigrant army. Suspicious patroles were remarked; but as they repeated the watchword for the night, they were allowed to pass. The republican troops were conducted in silence along an unguarded quarter of the shore, till they were enabled to surprise one of the posts of the garrison, where they found the artillery men fast asleep. Their matches were seized, and the lanthorn intended to give the alarm to the British fleet was extinguished. The fort was speedily in confusion. Some regiments threw away their arms, and went over to the republicans; others even massacred their own officers. A considerable number, however, maintained a violent conflict for some time before they surrendered. Puisaye escaped on board the fleet. The Count de Sombreuil was taken; and this accomplished young man was soon after put to death, along with the other emigrant officers and all the Chouans that were found in the fort. The bishop of Dol was also put to death, with his clergy who accompanied him; but many of the private soldiers of the emigrant army made their peace with the republicans, by pretending they had been compelled to engage in the expedition.

The British fleet, with transports and troops, still hovered upon the French coast, and made an unsuccessful attempt upon the island of Noirmontier. In consequence of the season of the year, however, it returned home in December, after evacuating a small island called *L'Isle Dieu*, which the troops had for some time occupied.

246
Successes of the French in Germany.

On the side of Germany the fortress of Luxembourg surrendered on the 7th of June, after having been in a state of blockade since the preceding campaign. The French were now in possession of the whole left bank of the Rhine excepting the city of Mentz, which they attacked in vain, because the Austrians could at all times throw succours into it from Fort Cassel on the opposite bank of the river. Finding the capture of Mentz impossible in these circumstances, the French resolved to cross the Rhine, to invest the city on all sides. The enterprise, however, was delayed for some time, till the result of the British expedition to Quiberon should appear. In the month of August, General Jourdan forced the passage of the Rhine at Dusseldorf, at the head of what was called the army of the Sambre and Meuse. After driving before him three Austrian posts upon the Lahn, he crossed the Mein, and completely invested Mentz and Cassel. Pichegru, in the mean time, crossed the river, with the army of the Rhine and Moselle, near Manheim, of which city he immediately took possession. But the French generals soon found their forces inadequate to the undertaking in which they were engaged. A considerable detachment of Pichegru's army, after driving the Austrians under General Wurmser from a post of some importance, began to plunder, and went into confusion. The Austrians being informed of this circumstance, returned to the charge, and defeated the French. General Clairfait also, having violated the line of neutrality, came upon the rear of Jourdan's army, and took a considerable part of his artillery. Both the French generals now retreated. Jourdan was rapidly pursued by Clairfait till he returned to Dusseldorf, where he maintained his ground. Pichegru recrossed the Rhine near Manheim, leaving a garrison of 8000 men in that city. The Austrians advanced in all directions. Manheim was taken after a vigorous siege. The French were driven from the neighbourhood of Mentz. The Palatinate became the theatre of war, and the Austrians seized the country called the *Hundsruck*, south of the Rhine as far as Landau and Treves. After various engagements, in which little more ground was lost or won, the two parties entered into an armistice for three months.

247
They receive a check.

On the 28th of August a treaty of peace was concluded between the French Republic and the Landgrave of Hesse Cassel, on condition that he should send no more troops to Great Britain for the prosecution of the war. It is not a little singular, that peace was concluded with the Elector of Hanover at this period upon similar terms. The Duke of Wirtemberg, and some other princes of the empire, also began to treat; but the negociations were broken off in consequence of the reverse of fortune now experienced by the French.

The Directory, however, resolved to continue the war with vigour, and vast preparations for the approaching campaign were made during the winter. The Mountain party being once more possessed of power, its members exerted themselves with their usual energy. Such, however, was the turbulent character of these men, that they could not long submit peaceably to any government, and soon became weary of that Directory whom they themselves had established. They held clubs in all quarters, and were continually disturbing the public tranquillity. For some time the government supported them. The Parisians, after the 5th October, no longer dared to avow openly their dislike to the Jacobins; but they were understood to express this sentiment by wearing green silk cravats, and by applauding with much vehemence at the public spectacles the air called *Le Reveil du Peuple*. The Directory now prohibited, by an edict, as tokens of royalism, the wearing of green cravats, or the performing at any of the theatres the air now mentioned, though the sentiments it contained were entirely republican. The Directory also ordered in its stead, that the Marseillois hymn, and other popular songs, should be performed every evening at all the theatres. The Parisians shewed their disapprobation of the Directory by maintaining a profound silence during the performance of these songs,

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Ridiculous conduct of the Directory.

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songs, which had never failed till that period to excite bursts of applause. The Directory soon became ashamed of this ridiculous contest, and in a few weeks recalled their edict. Indeed they found it impossible to give countenance for any long period to the restless and innovating spirit of the Jacobins, who continually wished and attempted to return to revolutionary, that is, to violent measures against their antagonists. In the south, in particular, the present supremacy of the Jacobins produced very pernicious effects. Freron, who had deserted them after the death of Robespierre, and became one of their most violent adversaries, thought fit to return to their party before the 5th October, and was sent to Toulon with full powers of administration. Here he dismissed the municipality that had been elected by the people, restored the Jacobin clubs, and proceeded to imprison all suspected persons as in the days of Robespierre. These measures produced a violent reaction on the part of the enemies of the Jacobins. Assassinations became frequent, and many persons began to leave the country. The Directory was alarmed by the many complaints against the Jacobins or terrorists that came from all quarters, and resolved to aim at popularity by deserting a set of men who could not be prevailed upon to act with moderation. Freron was recalled from Toulon, and more manageable men were sought out to replace the more violent Jacobins, who were in general dismissed from the service of government.

250 Measures taken against the Jacobins.

The Directory proceeded farther, and acknowledged, by a public resolution, that its confidence had been abused. The minister of police was ordered to remove from Paris the members of former revolutionary tribunals, and others who now acted as leaders of the Jacobins, or *anarchists* as they were called. A body of troops, amounting to 10,000 men, called the *legion of police*, that had acted against the Parisians on the 5th October, and was now devoted to the Jacobins, was ordered by the Directory, with the authority of the legislature, to join the armies on the frontiers. These men refused to obey the order; but they were reduced to submission by some troops that had been brought to the neighbourhood to provide against such an event. The more violent Jacobins were enraged, but not intimidated, by these measures, and began to organize a plot for the overthrow of the Directory and of the majority of the councils, who had now deserted them. They were not prepared for action, however, before the month of May, and by that time their designs were discovered and counteracted. On the 10th of that month the guards were increased, and bodies of cavalry stationed around the Luxembourg and the Thuilleries. The Directory at the same time informed the Council of Five Hundred, by a message, that a dreadful conspiracy was prepared to burst forth on the following morning. At the sound of the morning bell, which is every day rung, the conspirators were to proceed in small parties of three or four men to the houses of such persons as they had marked out for destruction. After assassinating those persons, the whole parties were to unite, and to act against the Directory, whose guard they apprehended they could easily overpower. The conspirators had appointed a new Directory and a new legislature, to consist of the most violent of their own party. Among the leaders of this conspiracy, who were now arrested by order of the Directory, was Drouet the postmaster of Varennes, whom we formerly mentioned as having arrested the unfortunate Louis XVI. when attempting to escape to the frontiers. Along with him were Babeuf, Antonelle, Pelletier, Gaudet, Julien, General Rossignol, Germain, D'Arthe, Laignelot, and Amar, who had been a member of the committee of general safety along with Robespierre. Vadier and Robert Lindet were also engaged in the conspiracy, but they made their escape. Drouet also escaped by the connivance of the Directory, as was generally understood; but the rest of the conspirators were removed for trial to the high national court at Vendome, where they were condemned. At the period of their removal thither, a new attempt was made by their party for their rescue. About 600 men entered the camp at Grenelle near Paris, and endeavoured to prevail with the soldiers to join them in an insurrection. This attempt was altogether unsuccessful. A few of the insurgents were killed, and the rest fled.

251 Moderate party.

These defeats of the Jacobins, and the discredit under which they were again brought, encouraged the moderate party in the two legislative councils to attempt to repeal the last decrees of the Convention, which had at once granted them an amnesty, and confirmed all the laws which, by confiscating the property of emigrants, excluded their relations from the succession. The discussion lasted many days; but the result was, that the law with regard to emigrants remained on the former footing; and the only point which the moderate party were yet able to carry was a modification of the decree to this extent, that those terrorists were declared incapable of holding public offices who owed their safety to the amnesty.

252 Distressed state of the finances.

The state of the finances now began to occupy the French government in a very serious manner. During the government of Robespierre, while the credit of the assignats was preserved by the influence of terror, or by the sale of the church lands, and the property of emigrants, little attention was bestowed upon this subject. When money was wanted, more assignats were fabricated; and as few or no taxes were demanded from the people, no enquiry was made about the public expenditure. But when the boundless extravagance of the agents of government had loaded the circulation with assignats till they became of little or no value, it became a very difficult question how the public service was hereafter to be supported. A new paper currency, called *rescripts*, was first adopted. These were orders on the treasury for cash, payable at certain periods. But their credit soon passed away, as the treasury had no means of fulfilling its engagements. The Directory complained very bitterly, in a message to the Councils, of its distresses, and of the want of funds to carry on the approaching campaign. In consequence of this message, a law was passed, on the 25th of March, authorising the sale of the remainder of the national domains for the price that had been fixed upon them at an early period of the revolution, amounting to about twenty-two years purchase. A new paper currency, called *mandats*, was to be received in payment. But the credit of government was now gone. The mandats instantly lost in all private transactions one-fourth of their value, and they soon fell still lower. This, however, produced a great demand for national pro-

 perty,

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perty, which was thus about to be sold far below its value. To prevent this effect, the legislature broke its engagements, and decreed, that one-fourth of every purchase should be paid, not in mandats, but in cash. This decree put a stop both to the sale of national property and to the circulation of mandats.

253 Reasons of the flourishing state of agriculture.

Recourse was next had to taxation; but this was attended with much difficulty. By the war, and the violent government of Robespierre, the French commerce had been in a great measure ruined. Industrious men, who possessed any capital, had therefore turned their attention to the cultivation of land. Many circumstances led to this. By the emigration of the nobles, and the confiscation of the church lands, the farmers were left with no landlord but the government; which, being supported by assignats, paid little attention to any other source of revenue. Hence they paid no rent, and speedily rose into opulence. The revolutionary government, which kept the inhabitants of the towns under dreadful bondage, was scarcely felt by the inhabitants of the country, who thus enjoyed the advantage of exciting no suspicion in the rulers, and of paying neither rent nor taxes. The law which declared assignats to be a legal tender of payment, was a great source of profit to the cultivators of the soil. They contrived to sell the produce of their farms only to such as offered them ready specie; while, at the same time, they paid their rents, where the landlord had not emigrated, in assignats, which they obtained at a trifling price. Hence it usually happened, that while the tenant enjoyed affluence, his miserable landlord was reduced to the necessity of selling his moveables to buy a portion of the grain that grew upon his own estate, or was tempted to sell the estate itself, at an undervalue, to obtain the means of emigration. [illegible] and other circumstances, the whole industry of the French nation came to be directed towards agriculture. Their country was accordingly well cultivated; but as the riches of agricultural nations are not easily subjected to taxation, the French Directory now found it impossible to carry on the schemes of ambition and of conquest, which they had already formed, without relying for resources upon the plunder of the neighbouring states, which speedily rendered their armies odious in all those quarters of Europe to which they penetrated.

254 National Institute.

Amidst their preparations for the approaching campaign, the Directory attempted to increase their own reputation at home, by establishing what is called the *National Institute*; which is a society of men of letters, under the protection of the government *. Into this body were collected the most celebrated literary characters in the nation that had escaped the fury of the Mountain Party. Among these were La Place, Lalande, Fourcroy, Bertholet, Volney, Dolomieu, and others, well known throughout Europe. The first public meeting of the Institute was held, with great splendour, on the 4th of April, in the hall of the Louvre, called the *Hall of Antiques*. The ambassadors of Spain, Prussia, Sweden, Denmark, Holland, America, Tuscany, Genoa, and Geneva, were present. The members of the Directory attended in their robes, and their president made a speech of installation, declaring the determination of the executive power to protect and encourage literature and the arts. Dusaulx, the president of the Institute, replied, in a speech in which he declared the resolution of the members to labour to give lustre to the republican government by their talents and productions. Fifteen hundred spectators applauded the speeches with enthusiasm, and vainly imagined that all the evils of the revolution were terminated, and that their country was now entering upon a career of unexampled glory and prosperity.

* See INSTITUTE, *Suppl.*

255 Overtures of the British government

At this period the British government made an approach towards a negociation with France. On the 8th of March Mr Wickham, the minister plenipotentiary to the Swiss Cantons, transmitted to Barthelemy, ambassador from the French Republic to the Helvetic body, a note containing three questions. Whether France would be disposed to send ministers to a congress to negociate peace with his Britannic Majesty and his allies? Whether France would be disposed to communicate the general grounds on which she would be willing to conclude peace, that his Majesty and his allies might consider them in concert? and, lastly, Whether France would desire to communicate any other mode of accomplishing a peace? The note concluded with a promise to transmit to the British court whatever answer should be returned; but declared, that Mr Wickham was not authorised to enter into any discussion upon these subjects.

256 Insolently rejected by the Directory.

On the 26th of the same month Barthelemy returned an answer in name of the French Directory. This answer began by complaining of insincerity in the proposal made by the British court, seeing its ambassador was not authorised to negociate, and that a congress was proposed, which must render negociation [illegible]. It proceeded to state the ardent desire of the D[illegible] for peace; but asserted, that it could listen [illegible] posal for giving up any territory that [illegible] by the constitutional act to form a part [illegible] (alluding to the Austrian Netherlands) [illegible] however, that other countries occupied [illegible] armies, and political or commercial inte[illegible] come the subject of negociation. [illegible] the Directory declared its readiness [illegible] proposals.

To this answer no reply was sent; [illegible] court published a note, of which copies [illegible] to the foreign ministers residing at London [illegible] the spirit of the Directors answer [illegible] and also the refusal even to negociate about the [illegible] of foreign territory, under pretence of an internal regulation. It was added, with truth, that while such dispositions were persisted in, nothing was left but to prosecute a war equally just and necessary; but that, when more pacific sentiments should be manifested, his Majesty would be ready to concur with his allies in taking measures for establishing a just, honourable, and permanent peace.

257 French armies.

The French Directory had succeeded, during the winter, in reducing the western departments into subjection. The emigrant expedition from England had induced the royalists once more to try the fortune of war; but, after various defeats, their leaders, Charette and Stofflet, were taken, and put to death on the 29th of March, and the insurgents were suppressed in all quarters. The French government being thus left without an enemy at home, was enabled to make great efforts on the frontiers. The military force of the Republic was divided into three armies. On the Lower Rhine, the army of the Sambre and Meuse was chiefly stationed about Dussel-

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Duſſeldorf and Coblentz, and was commanded by Jourdan. Moreau commanded the army of the Rhine and Moſelle, in the room of General Pichegru, who had been diſmiſſed from his command. This army was ſtationed on the Upper Rhine, and from Landau to Treves. The third and laſt army was ſtationed on the coaſt of Italy, from Nice towards Genoa, and now received Bonaparte as its commander. The name and the actions of this man muſt hereafter fill ſo large a ſpace in the detail of this eventful period, that it is neceſſary to pay ſome attention to his perſonal hiſtory.

258 Bonaparte

A Corſican gentleman, a lawyer by profeſſion, but who had appeared in arms under the celebrated Paoli in defence of the independence of his native iſland, was the father of Napolone Bonaparte. Napolone was born at Ajaccio in 1767; and by the intereſt of M. de Marboeuf, the French governor of the iſland, he was placed for his education at the celebrated military academy of France (*Ecole Militaire*), which has produced ſo many accompliſhed men. At a very early period of life he preſented himſelf as candidate for a commiſſion in the artillery, and was ſucceſsful, being the 12th on the liſt out of 36 victorious candidates. In conſequence of this event he ſerved two or three years in the French army as a lieutenant in the regiment of La Fere. Bonaparte having riſen to the rank of captain of artillery, returned to Corſica after the revolution, and was there elected lieutenant-colonel of a corps of Corſican national guards. Here he formed a connection, which had nearly proved fatal to him, with General Paoli, the friend of his father. He reſented the treatment which [illegible] from Robeſpierre's government, and en[illegible] into his intereſts as to write the remon[illegible] which was tranſmitted by the municipality to the Convention, againſt the decree which declared the [illegible] enemy to the Republic. In conſequence of [illegible] was at one time iſſued for his arreſt by [illegible] of the Convention. He made his [illegible] however, on this occaſion; and reſolved to ad[illegible] to the intereſts of France, in oppoſition [illegible] at this period formed [illegible] of Corſica. He embarked with the [illegible] of his family for France, and arrived [illegible] time when Lord Hood was in poſſeſſion [illegible] Saliceti, a deputy from Corſica to the Convention, introduced him to Barras, who was now ſuperintending the ſiege of Toulon. Here Bonaparte was advanced to the rank of general of artillery; and, under Dugommier, directed the attack of the various fortified poſts around the city. He was afterwards employed for a ſhort time againſt the royaliſts in the weſt of France; and we have already mentioned, that he was at the capital, and aſſiſted Barras in the conteſt between the Convention and the Pariſians on the 5th October. Hence he was regarded with diſlike by the moderate party, and repreſented as an unprincipled adventurer, brought forward to ſupport the terroriſt faction. He had many enemies, therefore, at the commencement of his career, and his character was treated with much freedom. The ſcandal of the times went ſo far as to aſſert, that he owed his preſent preferment, not ſo much to any talents he had yet had an opportunity to diſplay, as to his marriage with Madame Beauharnois, a beautiful French woman whom Barras had taken under his protection.

259 Takes the command of the army of Italy.

The French army of Italy amounted at this time to 56,000 men. Bonaparte at his arrival found it ill equipped, and the troops mutinous for want of pay and neceſſaries. He addreſſed them, however, in the true ſtyle of military enterpriſe, "If we are to be vanquiſhed, we have already too much; and if we conquer, we ſhall want nothing;" and ordered them to prepare for immediate action. His opponents, however, anticipated him in the attack. The Auſtrians employed in the defence of Italy, under General Beaulieu, are ſaid to have more than equalled the French in numbers. To theſe were united the King of Sardinia's army, under Count Colli, of 60,000 regular troops, beſides the militia of the country, which was now embodied, and a ſmall body of Neapolitan cavalry, amounting to about 2500 men. General Beaulieu began the campaign, on the 9th of April, by attacking a poſt called Voltri, which the French poſſeſſed, within ſix leagues of Genoa. They defended themſelves till the evening, and then retreated to Savona. Next morning Beaulieu, at the head of 15,000 men, preſſing upon the centre of the French army, was completely ſucceſsful till one o'clock afternoon, when he reached a redoubt at Montenotte, which was the laſt of their entrenchments. This redoubt contained 1500 French. Their commander, Rampon, prevailed with them, in a moment of enthuſiaſm, to ſwear that they would not ſurrender; and the conſequence was, that they arreſted the progreſs of Beaulieu for the remainder of the day. During the night, Bonaparte ſtationed his right wing under La Harpe, a Swiſs exile, in the rear of the redoubt of Montenotte, which ſtill held out, while he himſelf, with Maſſena, Berthier, and Salicetti, advanced by Altara, to take the Auſtrians on their flank and rear. Beaulieu, in the mean time, had received powerful reinforcements, and on the morning of the 11th renewed the attack on the French under La Harpe; but Maſſena ſoon advancing upon the flank of the Auſtrians and Sardinians, they gave way on all ſides. Two of their generals, Roccavina and Argentau, were wounded. They loſt 2500 priſoners, and were purſued beyond Cairo, of which the French took poſſeſſion on the following day.

260 His ſucceſs.

On the 13th at day-break, the defiles of Milleſimo were forced by the French General Augereau; and, by a ſudden movement, General Provera, a knight of the order of Maria Tereſa, at the head of 1500 Auſtrian grenadiers, was ſurrounded; a circumſtance which proved not a little embarraſſing to the French army. For this reſolute officer, inſtead of ſurrendering, inſtantly withdrew to a ruined caſtle on the top of the mountain, and there entrenched himſelf. Augereau brought up his artillery, and ſpent many hours in attempting to diſlodge him. At laſt he divided his troops into four columns, and endeavoured to carry Provera's entrenchments by ſtorm. The French loſt two generals, Banel and Quenin, and Joubert was wounded in this attempt, which proved unſucceſsful. Provera paſſed the night in the midſt of the French army, which had been prevented by his obſtinate reſiſtance from coming to battle. On the 14th the hoſtile armies faced each other, but a diviſion of the French troops was ſtill occupied in blockading General Provera. The Auſtrians attempted to force the centre of the French, but without ſucceſs. Maſſena, in the mean time, turned the left flank of their left wing near the village

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village of Dego; while La Harpe, with his division in three close columns, turned the right flank of the same wing. One column kept in awe the centre of the Austrians, a second attacked the flank of their left wing, while the third column gained its rear. Thus was the left wing of the combined army completely surrounded and thrown into confusion. Eight thousand men were, on this occasion, taken prisoners, and General Provera at last also surrendered.

These victories were not gained over a timid or an inactive adversary. On the morning after his fatal defeat at Millesimo, Beaulieu made one of those spirited efforts which often retrieve and alter the fortune of war. At the head of 7000 chosen Austrian troops he attacked, at day-break, the village of Dego, where the French reposed in security after their success. He took the village; but the French having rallied under General Massena, spent the greater part of the day in attempting to retake it. They were thrice repulsed, and one of their generals, Causse, was killed. Towards evening, however, Bonaparte in person having brought up reinforcements, the post was retaken, and the Austrians retired with the loss of 1400 made prisoners.

Bonaparte had now thrown himself between the Austrian and Sardinian armies. By the possession of the strong post of Dego, his right was secured against the efforts of Beaulieu, while he was enabled to act with the mass of his force against the Piedmontese troops. His enterprises in this quarter were facilitated by the exertions of Augereau, who had opened a communication with the valley of the Tanaro, where Serrurier's division was approaching the town of Ceva, near which the Piedmontese had an entrenched camp defended by 8000 men.

On the 16th Augereau attacked the redoubts which covered this camp, and took most of them; which induced the Piedmontese to evacuate it during the night, and on the 17th Ceva was entered by Serrurier. Count Colli now retreated to cover Turin; making choice, however, of the strongest posts, and fighting in them all. He was able, on the 20th, to repulse Serrurier; but on the 22d Bonaparte, still pressing on the Piedmontese general, defeated him near Mondovi, and entered that place. The retreating army next endeavoured to make a stand, with its head quarters at Fossano, and its wings at Coni and Cherasco. On the 25th Massena advanced against Cherasco, which was speedily evacuated. Fossano surrendered to Serrurier, and Alba to Augereau.

261 Armistice with Sardinia succeeded by

Previous to these last movements, however, Count Colli, on the 23d of April, had written to Bonaparte, requesting an armistice, to allow the King of Sardinia an opportunity of negociating a peace. The French army was now within 26 miles of Turin; and that prince saw himself suddenly reduced to the necessity of standing a siege in his capital, or of accepting such terms as the conqueror might think fit to impose. Bonaparte granted an armistice; on condition that the three fortresses of Coni, Ceva, and Tortona, should be delivered up to him, with their artillery and magazines, and that he should be allowed to cross the Po at Valentia. The armistice was signed on the 29th, and it was followed by a formal treaty with the French Republic, which was concluded at Paris on the 17th of May. The conditions imposed by this treaty upon

262 A formal treaty.

the King of Sardinia were humiliating and severe. He gave up to France for ever the duchy of Savoy, and the counties of Nice, Jenda, and Bretueil. He gave an amnesty to all his subjects that were prosecuted for political opinions. He agreed that the French troops should have free access to Italy through his territory; and, in addition to the fortresses surrendered by the armistice, he gave up those of Exiles, Susa, Brunette, Assiette, Chateau Dauphin, and Alexandria, to be possessed by the French during the war; and they were authorised to levy military contributions in the territory occupied by them. He agreed to erect no fortresses on the side of France, to demolish the fortresses of Brunette and Susa, and to disavow his disrespectful conduct towards the last French ambassador.

In the mean time the French army advanced towards the Po. Beaulieu was deceived by the article in the armistice; which stipulated, that the French should be allowed to cross that river at Valentia, and made all his preparations for resistance in that quarter. Bonaparte laboured, by several evolutions, to confirm this error; and while the Austrian general waited for him near Valentia, in various well fortified positions, he advanced hastily into Lombardy, and had proceeded sixty miles down the river to Placentia, where he arrived on the 7th of May, before the direction of his march was discovered. He immediately seized whatever boats or other craft he could find, and effected his passage without difficulty, there being only a small party of Austrian cavalry accidentally on the opposite bank, and they fled at his approach. Beaulieu in the meanwhile had sent, when too late, a body of 6000 infantry and 2000 cavalry, to prevent if possible the French from passing the river; but Bonaparte, now on the same side of the river with themselves, met and defeated them on the 8th at the village of Fombio. Another body of 5000 Imperialists, advancing to the assistance of [illegible] Fombio, was met at Codogno, and repulsed by General La Harpe; but this officer was killed on the occasion. On the 9th Bonaparte granted an armistice to the Duke of Parma, on condition of his paying a contribution of 2,000,000 of French money, and delivering [illegible] quintals of wheat, 5,000 quintals of oats, and [illegible] oxen, for the use of the army. This prince also agreed to deliver up 20 of his best paintings, to be chosen by the French. This last stipulation was no sooner known in France, than many men of letters and artists remonstrated against it as both impolitic and useless. They contended, that it would render the French Republic odious to all Italy, without producing any advantage to compensate this evil, as the progress of the arts could not be promoted by removing their best productions from the scenes in which they originated. But the Directory was too much occupied by views of national aggrandisement to listen to considerations of this kind, and similar stipulations were ordered to be inserted in every future treaty; by which means the most valuable curiosities of Italy were gradually transferred to the French capital.

Beaulieu, now driven from the Po, crossed the Adda at Lodi,* Pizzighitone, and Cremona. He left some troops, however, to defend the approaches to Lodi. The advanced guard of the French attacked these on the 10th, and drove them into the town; which was entered in such close pursuit, that the Imperialists, on leaving

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ving it, had not leisure to break down the bridge over the Adda. At the other end of the bridge the Imperial army was drawn up, and thirty pieces of cannon defended the passage. The French generals, after a consultation, agreed that it could not be forced. But Bonaparte having demanded of his grenadiers if they were willing to make the attempt, they applauded the proposal, and he formed them into a close column. Taking advantage of a cloud of smoke which issued from the hostile artillery, they rushed along the bridge, which was about 100 yards in length, and were at the middle of it before they were discovered. Here a general discharge from the Austrians destroyed 700 men. The French column hesitated, and the carnage became terrible; but Massena, Berthier, Dallemagne, Cervoni, Lasnes, Dupat, and other officers, flying to the head of the column, urged on the soldiers, and pressing forward, broke into the ranks of the Imperial army, which immediately gave way, and fled in all directions. This exploit has been much celebrated. The intrepidity of the troops by whom it was accomplished is unquestionable; but how far the leader who urged them to such an enterprise is entitled to approbation may well be doubted. He had passed the Po with scarcely the loss of a man. The Adda is a very inferior stream, which has fords both above and below the town of Lodi. The river was actually crossed at one of these by Augereau with the cavalry, during the attack upon the bridge. With the delay of one day therefore the passage might have been effected without difficulty by the whole army, and there was no adequate motive to justify the lavish expenditure of blood which was here made; for the French army no longer pressed forward in pursuit of Beaulieu, but, after the surrender of Pizzighitone and Cremona on the 13th, returned upon Pavia and Milan [illegible] (A). These places opened their gates without [illegible] though the citadel of Milan held out for a [illegible].

It would seem that, in the original plan of Bonaparte's campaign, the utmost expected from his efforts [illegible] such an ascendancy in Italy as might induce the [illegible] princes and states of that country to desert the coalition against France, which all of them assisted with money and provisions, if not with troops. To accomplish this object, though he sent Massena in pursuit of Beaulieu as far as Verona, yet he himself now turned aside into Modena and the territories of the Pope. He took Ferrara, Bologna, and Urbino; and at last granted an armistice to his holiness and the Duke of Modena, on the usual conditions of large contributions of money, paintings, and curiosities. From the Pope he farther exacted the cession of the legations of Bologna and Ferrara, and possession of the citadel of Ancona. His march into the Roman territory so alarmed the Neapolitan cabinet, that it now solicited peace; and Bonaparte granted an armistice, without attempting to add to it the humiliating conditions to which the other Italian states were subjected. From the territories of the Pope, Bonaparte hastily advanced with a body of troops to Leghorn, in the neutral state of Tuscany, under pretence of driving out the English, whose property there he confiscated. By these measures the task assigned to Bonaparte was completed by the time the campaign upon the Rhine was begun. Mantua was still indeed in the hands of the Imperialists, but it was blockaded, and all Italy was now submissive to France.

French Revolution, 1796. 166 Successes of the French in Germany.

To diminish, if possible, the efforts of the French on the side of Italy, the Imperialists thought it necessary to renew the contest in Germany. An intimation was therefore sent to General Jourdan, that the armistice would terminate and hostilities commence on the 31st of May. At this time General Wartensleben opposed Jourdan; and the Archduke Charles commanded the army in the Hundsruck, which covered Mentz and Manheim, and was stationed against Moreau on the Upper Rhine. The French began their operations with a very artful stratagem, intended to draw the whole Austrian force to the Lower Rhine, that Moreau might have an opportunity of suddenly penetrating into Swabia, and consequently of carrying the war towards the hereditary territories of Austria. For this purpose Moreau remained quiet, while Jourdan began to act vigorously. On the 31st of May his left wing, under Kleber, issued from the lines of Dusseldorf, on the right bank of the Rhine, and, advancing towards the Sieg, defeated the Imperialists. Thereafter they were driven successively from the strong positions of Ukareth and Altenkirchen, and retreated across the Lahn. Jourdan, in the mean time, having advanced with his centre and right wing, forced the Austrian posts on the Nahe, crossed the Rhine, formed the blockade of the fortress of Ehrenbreitstein, and hastened forward as if about to form the blockade or siege of Mentz. By these movements the Archduke found himself in the hazardous situation of having Moreau in his front, while Jourdan, with a victorious army, commanded his rear. He therefore hastily crossed the river, leaving the fortresses of Mentz and Manheim to keep Moreau in check. Having joined the retreating army, he encountered Jourdan's advanced guard, which he compelled to retire after an obstinate conflict. Jourdan did not hazard a general engagement, but withdrew to his former positions, the Archduke pressing hard upon him, till he raised the blockade of Ehrenbreitstein, and crossed the Rhine in its neighbourhood, till Kleber, on the 20th of June, entered the lines of Dusseldorf, from which he had set out.

These movements were foreseen. For the instant that the Archduke withdrew from the Palatinate to drive Jourdan down the Rhine, Moreau ascended rapidly towards Strasburg; so that these hostile armies seemed to be flying from each other with all possible speed. On the 24th of June, Moreau effected the passage of the river opposite to fort Kehl. This was an enterprise of considerable difficulty; for a sudden swell, by covering a part of the islands with which the river abounds, had prevented the Austrians from being taken by surprise, as was originally intended. The entrenchments on such islands as were occupied by troops were speedily carried by the bayonet, and 2600 French landed on the opposite shore, but without cavalry or artillery. Here they were exposed to the attacks of the Austrian

(A) We think this conduct cannot be accounted for, but by the supposition of a very improper correspondence between Bonaparte and the Austrian officers.

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Austrian horse from the camp of Wilftedt, and to the fire of the cannon of the fort. They maintained their ground, however, and even acted on the offensive, till the boats, which had been sent back, returned with a reinforcement. The whole redoubts and the fort were then instantly taken by storm, or with the assistance of such cannon as had been found in the first redoubts at which the French arrived, and the Imperialists fled towards Offenburgh.

The departure of the Archduke to the Lower Rhine in pursuit of Jourdan, and the large detachments which had recently been sent towards Italy to oppose Bonaparte, now enabled Moreau to enter Swabia with a great superiority of force. The strong military positions, however, which the country affords, presented to him considerable difficulties. On the 26th of June he drove the Austrians from their camp of Wilftedt: and on the 27th he advanced with his army, in three columns, against another camp of 15,000 men in front of Offenburg. General Wurmser sent a strong reinforcement from Manheim to the assistance of these troops; but having encountered two of the French columns on its way, the reinforcement was defeated, and the camp at Offenburg was evacuated during the night. The Austrians made an obstinate stand at Renchen, near Philipsburg, on the 29th, but were at last compelled to retire with the loss of 1200 men taken prisoners, and several pieces of cannon. On the 2d of July a division of the French army, under General Laroche, succeeded in seizing the mountain Knubis, which is the highest point of the ridge of mountains called the Black Forest. On the 3d, after an obstinate conflict, the Austrians were driven from the pass of Friedenstadt; in consequence of which they lost all communication with the emigrant troops under the Prince of Condé, and other Imperial troops stationed on the Rhine towards Switzerland. On the 6th, the left wing of the French, under Desaix, encountered the Imperialists at Rastadt, where the Austrians, who had received some reinforcements from the Lower Rhine, made a very determined resistance; but were at last compelled to give way, and to retire to Ettingen.

The Archduke Charles now arrived in person with his army from the Lower Rhine, where he had left Wartensleben, but with inferior force, to oppose Jourdan. The French, under this general, had instantly resumed the offensive upon the departure of the Archduke. Kleber advanced from the lines of Dusseldorf, as formerly; while the centre and right wing crossed the Rhine near Coblentz. The posts of Ukareth and Altenkirchen were forced, and on the 9th of July the whole of Jourdan's army crossed the Lahn. On the 10th, Wartensleben was defeated near this river, after great slaughter on both sides, with the loss of 500 prisoners; and the French on the 12th entered Franckfort. The situation of the hostile armies was now become extremely important. The two Imperial armies were at no great distance from each other, and were placed in the centre between the armies of Moreau and Jourdan. Could the Archduke, who was commander in chief, have resisted one of these armies for a short time, at any strong position, by a detachment of his troops, while he precipitated himself with the mass of his force upon the other, it is probable that any farther invasion of Germany might have been prevented. But the activity of the French generals, whose progress could nowhere be resisted by partial efforts, prevented the possibility of executing such a plan. He was therefore under the necessity of making his final exertion for the present safety of Germany against Moreau at Ettingen, on the 9th of July, without having formed any junction with Wartensleben. The battle was most obstinately fought. The French were four times repulsed in their attempts to force the heights of Rollensolhe; and it was not till they had experienced a dreadful slaughter that they at last carried the field by the bayonet.

The loss of the battle of Ettingen compelled the two Imperial armies to retire eastward. After placing strong garrisons in Mentz, Manheim, and Philipsburg, the Archduke retreated through Swabia towards Ulm, where his magazines were placed. At every strong position, however, he made an obstinate stand; thus endeavouring to render the progress of the French under Moreau as tardy as possible. Wartensleben, with the other Imperial army, retired through Franconia, resisting Jourdan in the same manner. Many bloody battles were fought, of which it is here unnecessary to give a minute description. It is sufficient to remark, that the French were long successful in them all. They gradually pressed forward till Moreau's army compelled the Archduke to cross the Neckar, and afterwards the Danube, leaving the whole circle of Swabia in the rear of the French. Wartensleben was in like manner driven through Aschaffenburg, Wurtzburg, Schweinfurt, and found it necessary to cross the Rednitz, on the [illegible] of August, at Bamberg, to avoid the pressure of [illegible] army in his rear. This army [illegible] its right wing, under Bernadotte, [illegible] march, with his advanced posts [illegible] body of the army had driven [illegible] the Nab, and had reached Amberg [illegible] August.

Excepting a part of the mountains [illegible] French armies under Jourdan, [illegible] and [illegible] the whole [illegible] the [illegible] of Bohemia to the [illegible] alarm throughout Germany was extreme [illegible] of Wirtemberg obtained peace from the [illegible] dition of paying [illegible],000,000 of French money [illegible] circle of Swabia did the same, on engaging [illegible] 12,000,000 of livres, and to deliver 8,400 horses, [illegible] oxen, 100,000 quintals of wheat, 50,000 quintals of rye, 100,000 sacks of oats, 100,000 pairs of shoes, and a large quantity of hay. The Margrave of Baden obtained peace on similar terms. The elector of Bavaria and the circle of Franconia negociated, and offered large payments; and even the diet of Ratisbon sent a deputation to treat with the French generals for neutrality. The King of Prussia now entered into a new treaty with the French; the conditions of which were concealed, but its nature appeared in the advantage which he took of the progress of their arms to take possession of certain territories in Germany, and particularly of the suburbs of Nuremberg, under pretence of some antiquated title. Spain also entered into a treaty offensive and defensive with France, which was afterwards followed up by a declaration of war against Britain.

268 Danger of the house of Austria.

The danger of the house of Austria was now very great; and had Bonaparte, instead of being detained in Italy, by events of which we shall immediately take notice,

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tice, been able to cross the Tyrol by Inspruck, and to reach the banks of the Danube, there is little doubt that the Emperor must have submitted to such conditions as the French thought fit to impose. Deserted in all quarters by the members of the coalition, he still, however, retained an ally in Great Britain, whose riches, liberally bestowed in the form of a loan, extricated him from the present difficulties. Having the command of abundance of money, he was enabled to send one army after another to oppose Bonaparte in Italy, while he recruited his armies in Germany by extensive levies, and by taking into his pay the troops of those states that made peace with France.

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Masterly conduct of the Archduke.

The Archduke, having received powerful reinforcements, resolved to make a stand, on the 11th of August, against Moreau at Umenheim. A severe battle was fought during seventeen hours, and one of the wings of the Austrian army, under General Riese, even succeeded in occupying four leagues of territory in the rear of the French army; but the Archduke having received intelligence, in the mean time, that Wartensleben could not maintain his ground against Jourdan, he thought it necessary to continue his retreat, and to adopt new measures. On the 17th of August he left General La Tour, with a part of his numerous army, to oppose Moreau, and having crossed the Danube at Neuburg and Ingolstadt, he marched to Wartensleben's assistance to fall upon Jourdan with united forces. On the 22d he attacked Bernadotte at Teining, and forced him to retire towards Nuremberg. The Archduke was thus upon the right of Jourdan, while Wartensleben was [illegible] his front. The French general, finding his [illegible], began to retreat on the 24th. From [illegible] the finances, the French armies, at the commencement of this campaign, had been extremely ill [illegible] and ill paid. Hence the two armies of Moreau and Jourdan plundered, without decency or mercy, [illegible] places into which they entered. In Jourdan's [illegible] more especially, the want of discipline was ex[illegible] (A). Hence, when they began to retreat, loaded [illegible] with spoil, they suffered no less from the [illegible] inhabitants of the countries through which they passed, than from the military efforts of the hostile army. The Archduke having joined Wartensleben, was enabled to [illegible] off Nauendorf with reinforcements to La Tour, who opposed Moreau, and, in the mean time, he continued in person to pursue Jourdan towards Wurtzburg. Here the French made a stand, on the 3d of September, and a general engagement took place. Both parties suffered great loss, but more especially the French, who retreated during the night. Jourdan now fled by Fuldaw to Wetzlaer. Having crossed the Lahn, where he made some resistance, he descended along the banks of the Rhine, till his army, on the 17th, reached Coblentz and Dusseldorf, from which it had originally departed.

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Critical situation of Moreau.

The situation of Moreau's army was now uncommonly dangerous. He maintained his position, however, till the 17th of September; but he was undecided in his movements, and was obviously at a loss how he ought to proceed. He attempted, without success, to withdraw the Archduke from the pursuit of Jourdan, by detaching a part of his troops towards Nuremberg. Many attacks were made upon him, but all of them without success; and the Imperial generals at last gave way to him wherever he turned. Finding at last that Jourdan's defeat was irretrievable, and that Bonaparte did not arrive from Italy, he resolved to retreat. He had recrossed the Lech, to prepare for this event; but now suddenly passing it again, as if determined to advance farther into Austria, he drove back General La Tour as far as Landsperg. Having thus obtained freedom for his future movements, he set out in full retreat, proceeding between the Danube at Ulm and the lake of Constance. La Tour, however, soon pressed upon his rear. He found the passes of the Black Forest occupied by large bodies of Austrians and armed peasants, while Generals Nauendorf and Petrarsch harassed his right flank with 24,000 men. Once more therefore he turned upon La Tour, at Biberach, on the 3d of October, with great impetuosity, and having defeated him, took no less than 5000 prisoners; whom he was able to carry to France. He now continued his retreat; his right wing, under General Desaix, keeping Nauendorf and Petrarsch in check, while the rest of the army cleared the passages in front till he arrived at what is called the Valley of Hell (*Val d'Enfer*), a narrow defile, running for some leagues between lofty mountains, and in some places only a few fathoms in breadth. The centre of his army, advancing in a mass, forced this passage, while the wings resisted the Imperial troops under La Tour and Nauendorf. After this desperate effort he reached Fribourg on the 13th of October, and was soon compelled by the Archduke Charles, who had now arrived from the pursuit of Jourdan, to evacuate all his positions on the Swabian side of the Rhine, with the exception of Kehl, and a temporary fortification erected at Huningen, called a bridge-

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[illegible]ful ret[illegible]

(A) It would be improper to interrupt our military detail with the following information respecting the morals of Jourdan's army at this time; which, however, it is of importance for our readers to know. We have it from a German Count, who saw with his own eyes a considerable extent of the march and countermarch of the French through Franconia.

Almost every officer in Jourdan's army had a mistress; and such of them as by plunder could support the expence, gave balls, acted plays, and exhibited every species of gaiety when the army was not in actual motion. In all this there was nothing wonderful. The ladies, however, were not unfrequently pregnant; and as nursing would keep them from these assemblies, where their company could not be dispensed with by the soldiers of liberty, they drowned their new-born infants—*they drowned them publicly!* Our correspondent (the Count) saw two of the little victims, and he heard, from unquestionable authority, of several more. At a place within six miles of Nuremberg, a Prussian parish-minister, who was also a sort of justice, endeavoured to save one innocent, and was thrown into the river and fired at by the French, when his parishioners endeavoured to save him. He had the happiness, however, to save the child, and was allowed to keep it, the mother never enquiring after it!

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bridge-head (*tete de pont*), though there was no bridge at that place.

The Imperial troops, in the mean time, had taken advantage of the defenceless state of the French frontier to cross the Rhine at Manheim, and to advance in various detachments to Weissemburg, Seltz, Hagenau, and almost to the gates of Strasburg, levying contributions and taking hostages wherever they came. These detachments being now recalled, the Archduke resolved to terminate the campaign by the capture of Kehl, and of the fortification at Huningen. But this proved no easy task. As the communication with the French side of the river was open at both places, the divisions of Moreau's army did duty at them by turns. A great part of the winter was spent in fruitless attempts, on the part of the Austrians, sometimes to take them by storm, and sometimes to reduce them by the forms of regular siege. Different sallies were made by the French, and immense numbers of men were lost on both sides by the sword, and by the severity of the season. It was not till the 10th of January that the French agreed to evacuate Kehl, and the fortification at Huningen was not given up till the succeeding month.

During the invasion of Germany that has been now mentioned, and the reverses that were suffered by the French armies there, Bonaparte still continued to gain victories in Italy. The success and the wonderful fortune of this man, require that we should give some account of the arts by which he was enabled, so unexpectedly, to triumph over the most experienced military commanders of the age in which he lived. In the military art three orders of battle, or forms of drawing up an army, have been chiefly adopted by those nations whose force has principally consisted of foot soldiers. The first form or mode consists of arranging the troops in a deep line; that is, with from 16 to 30 men placed close behind each other. This is the most ancient and simplest order of battle. It was carried to perfection by the Greeks, under the name of the *Phalanx*; and, when the soldiers were armed with the long spear, it was extremely formidable. It left little to the skill of the general, except the choice of the ground where he was to fight, and made all to depend upon the steadiness of the troops. It was attended with these disadvantages, however, that an army thus drawn up commanded very little territory, and that if its ranks happened to be broken by unequal ground, or an uncommon effort of the enemy at a particular quarter, its parts could not easily be re-united, and it infallibly went into confusion. In modern times, this order of battle cannot be adopted with success on account of the facility with which it is broken by artillery, and the slaughter to which it exposes the troops from every kind of fire arms. The second, or modern order of battle, consists in forming a front of an immense extent, with only two or three men in depth, and usually supporting these by another, and perhaps a third equally slender line, at a considerable distance in the rear. Troops thus drawn up derive the greatest possible benefit from their own fire arms, and suffer the least loss from those of the enemy. They provide for their own subsistence by covering an immense track of country. Their battles are not sanguinary, as they are seldom very closely engaged; and in case of a defeat, little loss is suffered, because they can scatter themselves over a wide space, as the rear protects the advanced body; and as the troops in a long line can seldom all be engaged at once, they are supported by each other in a retreat. This order of battle, however, is easily broken; and the moment the flank of an army is turned, it is under the necessity of retreating, as troops cannot speedily be brought from other quarters to face the enemy there. The last order of battle consists of dividing an army into columns of a narrow front and very great depth, and of stationing the columns at some distance from each other, with a second set of columns opposite to the intervals between the first. This arrangement is superior to the phalanx, in this respect, that it does not expose an army to disorder by inequalities of ground, by the turning of its flank, or even by the defeat of one of its parts. The celebrated Epaminondas won the battles of Leuctra and Mantinea, by forming a part of his troops, on each of these occasions, into a strong column, which, by its great depth, and the mechanical weight of its shock, broke through the Spartan phalanx. The Romans are known to have owed their military success, in a great measure, to the arrangement of their legion. It was drawn up upon the principle now mentioned; and tho' the columns were only 16 men in depth, it was confessedly superior to the phalanx. In modern times, however, this order of battle is attended with great difficulties. It must reduce an army to embarrassment with regard to provisions from the smallness of territory which is thus occupied, and it exposes the troops in an engagement to dreadful destruction from the [illegible] missile weapons which are now employed. [illegible] enterprise they must instantly carry [illegible] undone, as the fire of a few guns [illegible] or redoubt would exterminate [illegible] With all its imperfections, however, [illegible] of battle has at times been employed by [illegible] It was the favourite arrangement of [illegible]phus; and his troops were drawn up according [illegible] the battle of Lutzen, where he himself was killed, [illegible] his army was victorious. The celebrated M[illegible] Montrose also used it on more than [illegible] it was now adopted in all important [illegible] Trusting to its success, he pushed his columns into the midst of the Austrian army at Millesimo, and fairly captured one of its wings. He ventured farther to throw himself into the centre, between the Austrian and Sardinian armies, and to vanquish the one, by acting against it with his whole troops while separated from the other. Being careless about the shedding of blood, he never hesitated to expose his whole army to utter ruin in case of a failure. The success of his battles, by enabling him to lay almost all Italy under contribution, gave him the means of maintaining the most steady and severe discipline over a well paid army. Filled with high notions of military glory, which he is said to have derived from the writings of Plutarch, he laboured to inflame, with the same spirit, the minds of his soldiers by proclamations, expressed in a very different style from the formal and more modest language of modern times. "Soldiers (said he, when he first entered Lombardy), you have rushed like a torrent from the summit of the Appenines, you have driven back and dispersed all who opposed your march. Your fathers, your mothers, your wives, your sisters, your sweethearts, rejoice in your success, and boast with pride of being related to you. But

272 Reflections on the different orders of battle.

274 His pompous proclamation.

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But remains there nothing more for you to effect? Shall posterity reproach us with having found a Capua in Lombardy? But I already see you rushing to arms; an unmanly repose fatigues you, and the days lost to glory are lost to your felicity. But let the people be tranquil: we are the friends of all nations, and more particularly of the descendants of the Brutuses, the Scipios, and the illustrious personages whom we have chosen as models. To restore the Capitol, to replace with honour the statues of the heroes who rendered it renowned, and to rouse the Roman people, become torpid by so many ages of slavery, such will be the fruit of your victories; they will form an epoch to posterity, and you will have the immortal glory of renovating the fairest portion of Europe. The French nation, free and respected by all the world, will give to Europe a glorious peace. You will then return to your homes and your fellow-citizens; who, when pointing to you, will say, *He was of the army of Italy.*"

275 Marshal Wurmser attacked.

At the commencement of the French invasion of Germany, Marshal Wurmser was sent into Italy to replace Beaulieu, who was removed from his command. On his arrival, he collected the wrecks of the Austrian army, and prepared, till he should receive reinforcements, to confine the French within as narrow limits as possible, by lines drawn from the lake of Garda to the river Adige. At the end of June, however, these lines were attacked and carried by Massena's division, which induced Wurmser to avoid farther exertion till he should receive an increase of force. In the mean time Bonaparte was a little disturbed by partial insurrections [illegible]. Soon after his arrival in Lombardy, [illegible] of Milan and of Pavia had risen in con[illegible] troops; but they were reduced to sub[illegible] bloodshed. In the beginning of July, [illegible] broke out in the Romagna. The [illegible] established their head quarters at Lugo, and [illegible] a party of French cavalry that was sent against [illegible]. It was not till Augereau had overcome them, [illegible] battle in which he [illegible] that [illegible]. The slaughter of these unhappy [illegible] great. Their town was given up to [illegible] found in arms were [illegible].

The first part of the month of July was spent by Bonaparte in commencing the siege of Mantua in regular form; and towards the close of that month he expected [illegible] capture. [illegible] however, he had ill calculated the immense military efforts which Austria, aided by the money of Britain, was capable of making. Twenty thousand troops had been sent from the Rhine, and other reinforcements were marching towards Italy from all quarters; so that Bonaparte, instead of being able to take Mantua, had speedily to defend himself against the force of a superior army to his own, that approached to raise the siege, and even threatened to drive him out of Italy. Wurmser's army descended from the Tyrol in two divisions. One half of it proceeded along the east side of the lake of Garda, and the other came by the west to cut off the retreat of the French, who were thus enclosed by the Austrians. On the 29th of July, at three o'clock in the morning, Massena was driven from the strong post of La Corona, on the east of the lake, while, at the same time, 15,000 Austrians drove the French from Salo, and afterwards took Brescia, with all the magazines and hospitals of Bonaparte's army.

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There was a fatal error, however, in the general plan of operations that had been formed by the Imperialists. Their army united was an overmatch for the French; but they had voluntarily divided it into two parts, placing Bonaparte between them. The error was instantly discerned, and taken advantage of by their antagonist. On the night of the 30th, he suddenly raised the siege of Mantua, and leaving a small body of troops to keep in check the Imperialists on that side, he marched rapidly westward, and on the first of August retook Brescia, with the magazines and hospitals. Having the mass of his army united, Bonaparte surpassed his antagonists in numbers wherever he encountered them. He prepared to attack the Imperialists on the 3d at Salo, Lonado, and Castiglione, but was anticipated by them. Having formed a large body of his troops into close columns, the Austrians, who were not yet aware of the nature of his mode of fighting, extended their line to surround them; a movement which enabled the columns to penetrate the Imperial army in all directions, and throw 278 He is defeated.
it into compleat disorder. The French took 4000 prisoners, and 20 pieces of cannon. The Imperial troops were here so completely defeated, that a considerable division of them having in vain attempted to retreat by Salo, which they found occupied by the French, wandered about in search of a road by which to escape; and having next day come to Lonado, they summoned it to surrender, upon the supposition that the greater part of the French army had gone eastward to encounter Wurmser. This was actually the case; but it so happened, that Bonaparte was in person at Lonado with only 1200 men. He was sufficiently perplexed by this accident; but having ordered the messenger to be brought into his presence, he threatened to destroy the whole division for having dared to insult the French army, by summoning its commander in chief to surrender. The stratagem was successful. The Imperial officers imagined that the whole army was in the place, and immediately, with their troops, laid down their arms, to the number of 4000 men.

Such is the account of this transaction, which we have from the partial pen of the panegyrist of Bonaparte, who writes the history of his campaigns in Italy; but we believe that the General has himself assigned the true reason of his success on this occasion, and others, where success could not be reasonably expected. In one of his intercepted letters, Bonaparte informs his correspondent, that the Austrian armies in Italy cost him more money than his own; and indeed it is not within the compass of supposition, that a body of veteran soldiers could have been intimidated to lay down their arms by so vain-glorious a threat as this, had not their officers been corrupted by French gold and French principles. The stratagem might have its effect upon the common soldiers, but it could not possibly impose upon their leaders, or upon the messenger who summoned Lonado to surrender.

On the 5th and 6th, Bonaparte attacked Marshal Wurmser, and drove him from Peschiera and the river Mincio. On the 7th, the Austrians were compelled to 279 Again defeated.
quit Verona, and to retire once more to the mountains of Tyrol. This contest, which had lasted more than six days, cost the Imperialists more than 20,000 men, upwards of 15,000 of whom were made prisoners. A part of the Emperor's troops had been levied in Gal-

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licia, the part of Poland which, in the partition of that country, had been allotted to Austria. These men seized the moment of defeat to quit a service which they disliked, and to go over to the French; a circumstance which greatly swelled the list of prisoners.

It was now necessary for the French to commence the siege of Mantua anew. The garrison in their absence had destroyed their works, and carried into the place 140 pieces of heavy cannon which they had left behind them, and procured a considerable quantity of provisions. The blockade was renewed; but the French, by the loss of their artillery, were unable to proceed to a regular siege; and by the beginning of the month of September, Marshal Wurmser, having received new reinforcements, was again enabled to attempt the relief of the place. Bonaparte having information of his intended approach, left sufficient troops to keep up the blockade, while he advanced northward with his army; and on the 4th of September drove the Austrians from the passes of St Marco and the city of Roveredo to the pass of Calliano, where they made their principal stand.

280 His masterly conduct after a third defeat.

Here a battle ensued, in which the French took no less than 6000 prisoners, and entered Trent as conquerors. Upon suffering this defeat, Marshal Wurmser adopted a measure which cannot be sufficiently approved of. Instead of retiring before the conqueror, who might have driven him to Inspruck, and arrived at a critical moment at the Danube, where Moreau, after much hesitation, had only commenced his retreat, he suddenly threw himself with his vanquished army into Bassano, upon the flank and rear of Bonaparte, and then advanced by hasty marches towards Mantua. He attempted to make a stand at Bassano on the 8th, but was defeated, and 5000 of his men were taken prisoners. He had still a considerable body of troops however. With these he pushed forward; and having fought different scattered divisions of the French at Cerea, Castellano, and Due Castello, he effected the passage of the Adige at

280 He enters Mantua.

Porto Legnano, entered Mantua with the wreck of his army, amounting to about 4000 infantry and 4500 cavalry. In this enterprise the Imperialists lost altogether 20,000 men; but the effect of it was, that it fixed Bonaparte in Italy, where he was obliged to remain watching and keeping under blockade the numerous garrison of Mantua. He hoped that its numbers would soon reduce it by famine to the necessity of a capitulation; but in this he was deceived, as the flesh of the horses, carried into it by Wurmser, afforded subsistence to the troops during a very long period.

In the mean time, the fame which their countryman Bonaparte gained by these victories, produced in the

281 Corsica revolts from Britain, and unites with France.

Corsicans a desire to change the British government for that of France. They accordingly displayed so mutinous a spirit, that the British Viceroy thought fit to evacute the island, which was no longer of any value to his government after all Italy had, in a great measure, submitted to the French. The Imperial subjects in Italy also, along with the inhabitants of Bologna, Ferrara, and Modena, who were completely corrupted by the false philosophy of the age, began now to republicanise themselves under the patronage of the French general. They sent deputies to a convention, levied troops, and abolished all orders of nobility.

The Emperor soon sent into the field a new army to attempt the relief of Mantua. In the beginning of November this army advanced under the command of Field Marshal Alvinzi, who advanced towards Vizenza on the east, seconded by General Davidovich, who descended with another division from Tyrol. Alvinzi had already crossed the Piava, when he was met by the French, and compelled to repass that river. But Davidovich, in the mean time, after several engagements, having succeeded in driving the French down the Adige towards Verona, Bonaparte was under the necessity of concentrating his forces. He now adopted his usual expedient of keeping one division of the hostile army in check, while he contended with the mass of his forces against the other. He left Vaubois with some troops to detain Davidovich, while he advanced in person against Alvinzi, who was now hastening towards Verona. He was met, on his way, by the Austrians at the village of Arcole. To seize this village, which could not be speedily turned on account of a canal, the French were under the necessity of passing a narrow bridge in the face of the fire of the Austrians. They made the attempt without success. Their officers rushed to the head of the column, and in vain attempted to rally the troops. Generals Verdier, Bon, Verne, and Lasnes, were carried off the field. Augereau advanced with a standard to the extremity of the bridge, but nobody followed him. At last Bonaparte, who in the mean time had sent Guieux with 2000 men to turn the village at two miles distance, hastened to the bridge of Arcole. Seizing a standard, he advanced at the head of the grenadiers, crying, "Follow your gene[illegible] They accordingly followed him to with[illegible] the bridge, when they were intimidated [illegible] fire of the Austrians, and their leader [illegible] to retire. Attempting to mount his [illegible] column, lest the Austrians should advance [illegible] pursuit, he was thrown into a morass, while [illegible] fire of the troops in the village; but here [illegible] ped, as the Austrians did not attempt to follow [illegible] advantage.

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282 Partial successes of the Austrians.

The village of Arcole was taken towards [illegible] ing by Guieux, and afterwards [illegible] On the following day (the 16th of Novem[illegible] stinate conflict ensued in its neighbourhood, in which nothing decisive was accomplished. On the 17th the Austrians, having pressed impetuously forward upon the centre of the French army, were taken by surprise upon their flank by the left wing of the French, which had been stationed for that purpose in ambuscade. Their left wing, however, maintained its ground till Bonaparte sent round a party of horse with twenty-five trumpeters to their rear, who, by the noise they made, induced the Austrians to believe themselves surrounded, and to fly on all sides in confusion.

283 They are defeated.

Here again appear evidences of treachery among the Austrian officers, though the battle of Arcole was the most severe which the French had yet fought in Italy, and extremely fatal to their officers, as well as to a multitude of their troops. During its continuance, Davidovich had succeeded in defeating Vaubois, who was opposed to him and Rivoli, and the blockade of Mantua was actually uncovered for a time. But Bonaparte now returned, after having driven Alvinzi across the Brenta, and the positions of Rivoli and La Corona were retaken, and Davidovich repulsed into Tyrol. General Wurmser, however, still held out in Mantua during

French Revolution, 1796. during the remaining part of the year; and the only fruit hitherto derived from so many victories was, that the French nation was led to look towards Bonaparte as its only invincible commander, upon whom all its hopes of conquest were to depend.

284 Negociation between Britain and France. During these military transactions, Great Britain had entered into a negociation with France. In consequence of passports obtained from the Directory, Lord Malmesbury arrived in Paris, and began the negociation with De la Croix the minister for foreign affairs. Tho' the Directory could not decently refuse to negociate, yet they were unwilling seriously to conclude a peace with Britain. On the other hand, the British ministry have since declared that, as individuals, they actually disapproved of a peace at this time, but that they thought it necessary both to negociate, and even to conclude a treaty, if proper terms could be obtained. In judging thus, they were certainly right; for the country at large, not seeing the danger of peace, was very desirous of it, whilst a desperate faction was constantly ascribing the continuance of the war to the criminal obstinacy of the British government. The negociation which was now set on foot opened the eyes of all but those who wished to sell their country to French regicides. Lord Malmesbury proposed, that the principle of mutual restitutions should be agreed upon as the basis of the treaty. After much useless altercation, and many notes had passed upon this subject, and also upon the question, how far Lord Malmesbury could negociate for the allies of Great Britain, from whom he had received no official powers, the Directory at last agreed to the general principle of mutual restitutions, but insisted that the objects of these should be specified. Accordingly, the British ambassador proposed, in two memorials, that France should relinquish the Austrian Netherlands, and offered to give up the French [illegible] settlements in return. An offer was also made to restore a great part of the Dutch foreign possessions, on condition that the Stadtholder's ancient authority should be acknowledged in that country. The Directory now required Lord Malmesbury to present the ultimatum of his conditions within twenty-four hours. On his complaining of this demand, he was informed, on the 19th of December, that the Directory would agree to no conditions contrary to the French constitution; and it was added, that his farther residence at Paris was unnecessary!

[illegible] broke off by the Directory.

286 Cape of Good Hope, with a Dutch squadron, taken by the British. During this year, Great Britain retained her usual superiority by sea. A British squadron, under Admiral Elphinston, had taken possession of the Dutch settlement at the Cape of Good Hope, on the 16th of September 1795. This settlement the Dutch wished eagerly to recover; and for this purpose they advanced money to enable the French to fit out a squadron to co-operate with them in an attack upon it. The French government took the money, but the squadron was never equipped. The Dutch themselves this year sent a squadron of seven ships of war, under Admiral Lucas, to attempt to reconquer the Cape; but being no match for the British squadron, and being likewise caught between two fires, without the possibility of escaping, the Dutch fleet, without firing a gun, was delivered up to the British admiral.

Notwithstanding the superiority of Great Britain by sea, the French, towards the close of this year, attempted an invasion of Ireland; but the plan was ill concerted, and, of course, unsuccessful. The whole conduct of it was intrusted to one man, General Hoche, and no second was prepared to occupy his place in case of any accident. The disaffected faction with whom the French meant to co-operate was not warned of their approach, and the fleet was sent towards a quarter of the country where the people were little disposed, or, at least, by no means prepared to receive them. Eighteen ships of the line, thirteen frigates, twelve sloops, and some transports, having 25,000 land forces on board, were employed in this expedition. When about to sail, it was detained for some time by a mutiny which arose in consequence of the enlistment of about 1,200 galley slaves. The fleet sailed on the 10th of December; but a ship of the line was lost in going out of Brest, and some of the rest were damaged. The frigate in which the commander in chief had embarked was separated from the fleet in a gale of wind; and the consequence was, that when the greater part of the fleet arrived at Bantry Bay, on the west coast of Ireland, nobody had instructions how to proceed. The troops and their officers wished to land, but the admiral, Bouvet, refused to comply with their request. Having remained several days upon the coast, he sailed for France, and arrived at Brest with a part of the fleet on the 31st of December. General Hoche did not reach Bantry Bay till it was too late, and therefore could not land. The fleet suffered great losses in its return. One ship of the line and two frigates foundered at sea, a frigate was taken by the British, and a ship of the line, after an engagement with two British ships, was run ashore to prevent her being captured.

287 Unsuccessful attempt by the French on Ireland.

At the commencement of the year 1797, the Archduke Charles was still occupied in the reduction of Kehl, and of the French fortifications opposite to Huningen. Moreau still commanded the army that opposed the Archduke; but General Hoche, after his return from the expedition to Ireland, was appointed to succeed Jourdan on the Lower Rhine. Bonaparte was still engaged in the blockade of Mantua, while the Austrian government was making vast efforts to recruit the army of Alvinzi after its defeat at Arcole, and to enable that General to make a last and desperate effort for the relief of Mantua. The young men of Vienna were urged to give their assistance on this important occasion, and 6000 of them marched into Italy as volunteers. Alvinzi's army amounted now to nearly 50,000 men; and he commenced his operations on the 7th of January, by skirmishing along the whole of the French line from below Porto Legnago upwards, to La Corona near the Lake Garda. He continued for some days to alarm the French at all points, and thus to conceal the plan of his future efforts. On the 10th Bonaparte was still at Bologna, on the other side of Mantua, taking precautions against the escape of Wurmser by that quarter, which, from an intercepted letter, he had learned was in contemplation. Being now informed of the approach of the Austrian army, he hastened to Mantua, and from thence to Verona, which was the centre of the line of his army that opposed Alvinzi. He arrived at Verona on the morning of the 12th; but as the Austrians continued to make their attacks upon all quarters at once, he was unable to penetrate the design of their leader. At last, on the 13th, the 1797.

288 Successes of the Austrians.

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the efforts of the Austrians began to assume a more formidable aspect on the lower part of his line near Porto Legnago; but on the evening of the same day he received intelligence, that the upper extremity of his line, where Joubert commanded, had been attacked by such an immense superiority of numbers, that there could be no doubt that the greatest number of the Imperial troops was concentrated there. The post of La Corona had even been forced, and Joubert compelled to withdraw to Rivoli, which he also abandoned.

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They divide their army;

The Austrians still persisted in their unfortunate plan of dividing their army, that they might have two chances of success. Ten thousand chosen troops, among whom were the Vienna volunteers, were destined under General Provera to penetrate to Mantua by Porto Legnago, at the lower extremity of the French line; while Alvinzi in person advanced with the mass of the army against Joubert at its other extremity. On the 13th all went well; Joubert was compelled to retreat; and he was so situated, that the easy capture of his whole division on the following day appeared a very probable event.

Bonaparte, in the mean time, having learned the state of affairs, left Verona in the evening of the 13th, having first ordered the whole centre of his army under Massena to follow him to the neighbourhood of Rivoli with all possible speed. Here he spent the night with his officers in arranging the order of battle for next day, and in occupying proper positions. At day-break of the 14th the attack was begun by Joubert's division, to the no small surprise of the Imperialists, who were not aware of the arrival of Bonaparte with reinforcements. The battle, however, was long and obstinate. The superiority of numbers on the side of the Austrians enabled them to defeat all the efforts of the French to turn their divisions. They at last succeeded in driving back upon the centre the two wings of the French army in considerable disorder. Alvinzi now attacked the centre, which scarcely maintained its position; and the Austrian wings advancing on both sides, completely surrounded the French army. The victory seemed already won; and it is said that Alvinzi dispatched a courier to Vienna to announce the approaching capture of Bonaparte and his army. Bonaparte indeed considered his own situation as very alarming; and is said to have meditated his escape across the Austrian right wing. From the nature of his order of battle, his troops had rather been concentrated than scattered by the repulse they had received, and it was therefore still in his power to make a desperate effort. Having formed three strong columns, he sent them against the Austrian right wing. They succeeded in penetrating it at different points; and it fled in such confusion, that having encountered a party of French that had not arrived in time to join the body of the army, 4000 Austrians laid down their arms in a panic, and surrendered themselves prisoners of war. Night put an end to any farther contest; but Bonaparte considering this quarter of his line as no longer in danger, departed to oppose General Provera, leaving Joubert to prosecute the victory now gained. This service he performed with great success. A detachment under General Murat having marched all the night of the 14th after the battle, seized Montebaldo in the rear of the position at Corona, to which a considerable division of the Austrians had retreated, while Joubert, next morning, attacked them in front. Finding themselves surrounded, they soon fell into confusion. Six thousand men were made prisoners, many were drowned in attempting to cross the Adige, and the remainder fled to Tyrol.

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And are defeated.

During this sanguinary contest on the upper part of the Adige, General Provera had forced his passage across the lower part of that river at Angiara near Porto Legnago, and compelled the French General Guieux to retire to Ronco. Augereau collected all the troops in the neighbourhood, and marched to attack Provera; but as he hastened towards Mantua, Augereau could only come up with his rear; of which, after an engagement, he took 2000 prisoners. On the 15th, however, General Provera arrived in the vicinity of Mantua. The city, which stands in a lake, was blockaded at the two points, by which it has access to the main-land called *St George* and *La Favorite*. Alvinzi was to have formed his junction with Provera at the post of St George. Receiving no intelligence of him, General [illegible] moned the French commander [illegible] on his refusal, endeavoured to [illegible] sault. Having failed in this attempt, [illegible] tention towards the post of La Favorite, [illegible] tacked on the morning of the 16th; while [illegible] who had perceived his arrival, advanced [illegible] of the garrison against the same [illegible]. But [illegible] time Bonaparte had arrived with reinforcements [illegible] neral Wurmser was repulsed (a) [illegible] pletely surrounded by the French, [illegible] sity of surrendering himself with his [illegible] war. The result of all these battles at Rivoli and Mantua was the capture of [illegible] prisoners and 60 pieces of cannon; and thus four Imperial armies had perished in Italy in the attempt to preserve Mantua. The capture of this city, however, was now inevitable, in consequence of famine. It surrendered by capitulation on the 2d of February. Bonaparte on this occasion endeavoured to acquire the reputation of humanity. To allow the French emigrants in the garrison to escape, he consented to an article in the capitulation that General Wurmser should be allowed to select and carry out of the garrison 700 men, who were not to be examined

(a) Marshal Wurmser had before this time begun to suspect that his plans were betrayed to the enemy. When he resolved to make his last sally to co-operate with Alvinzi, he kept his plan to himself; and in the morning of that day on which the army was to march out, he gave to each of the generals commanding the divisions (which we think were seven) his orders in a sealed packet. The troops marched at the hour fixed on, in so many divisions; and they were instantly attacked at all points by the enemy. Upon this, the old General said to a British officer of high rank, who was with him in the fortress, We are betrayed, make your escape by any means that you can. This anecdote was communicated to us through a channel which leaves no doubt of its truth in our own minds; but not being authorised to give the *names* of our informers, we thought it not right to insert it in the text. Its truth or falsehood may be easily ascertained.

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mined nor considered as prisoners; and the General himself was allowed to depart unconditionally.

292 The Pope perseveres in hosti-

In the meanwhile, the Pope, who of all the European princes had the best reason for disliking the French cause, uncautiously persevered in hostility, in the hope that some one of the Imperial armies might succeed in driving Bonaparte from Italy. Having recovered from the panic which induced him to solicit an armistice when the French first entered Lombardy, he had avoided concluding a treaty of peace, and attempted to enter into a close alliance with the court of Vienna. He procured officers to be sent from thence to take the command of his troops, and flattered himself with the vain hope of being able to make an important diversion in favour of the Imperial troops.

As the Emperor and the French were both preparing with all possible speed to renew their bloody contest on the frontiers of Germany, it was of importance to Bonaparte to leave all Italy in peace on his rear. On the 1st of February he sent a division of his troops under General Victor, along with what was called the *Lombard Legion*, consisting of Italians, to enter the territory of the Pope; and upon the surrender of Mantua Bonaparte followed in person. The troops of his Holiness made feeble resistance. The new raised Lombard legion was made to try its valour against them on the river Senis on the 2d. After storming their entrenchments, it took their cannon and 1000 of themselves prisoners. Urbino, Ancona, and Loretto, successively fell [illegible] the French. From the chapel at Lo- [illegible] Colli had carried most of the [illegible] and silver ar- [illegible] and the image of the [illegible] a curiosity to Paris. Bonaparte [illegible] through Macerata to Tolentino. He [illegible] messenger from the Pope with offers [illegible] a treaty with his Holiness on [illegible] treaty the conditions of the armi- [illegible] and in addition to the payments [illegible] Pope promised to pay 15,000,000 [illegible] horses, with as ma- [illegible] He also engaged to pay [illegible] the French envoy Bas- [illegible] at Rome, and to apologise [illegible] for that event.

294 Bonaparte reinforced.

The French [illegible] so unsuccessful in their late irruption into Germany, through Swabia and Franconia, that they now resolved to make their principal effort from Italy under Bonaparte. For this purpose, the Directory detached great bodies of the veteran troops that had fought under Moreau as secretly as possible through Savoy into Italy. The court of Vienna, however, was aware of the approaching danger, and gave the command on the side of Italy to the Archduke Charles, who of all their military leaders had alone of late been successful against the French. He brought along with him his best troops from the Rhine, and numerous levies were endeavoured to be made in all the hereditary states for his farther support. The war was now about to be carried into new territories, on which the house of Austria had scarcely hitherto beheld a foe. It was necessary that Bonaparte should once more attempt to scale the summit of the Alps. This immense chain of mountains, which takes its rise in the vicinity of Toulon, at first stretches northward under the names of *Piedmont* and *Savoy*. It then runs towards the east, forming the countries of Switzerland, Tyrol, Carinthia, and Carniola. The three last of these, passing along the head of the Adriatic, form the frontier in this quarter of the hereditary states of Austria. Between the mountains and the sea lies the level and fertile tract of territory which belonged to Venice. It is crossed by many large streams, which are fed by the melting snows of the Alps, and whose nature is this, that they are greatest in summer, and that their waters diminish during the frosts of winter.

295 Blunder of the Court of Vienna.

The council of war at Vienna now committed an important error in the plan of defence which it adopted. Instead of making a stand in the defiles of the mountains, the Archduke was sent down into the plain to defend the passages of the rivers. War is essentially an offensive art. Whatever the general purpose of hostility may be, it is always conducted with most success when the detail of its operations is so managed as to assume the form of enterprise and of vigorous attack. This arises not from any thing in the nature of the art of war, but from the immutable constitution of the human character. The strength of men who are fixed without motion in a particular spot, is subdued by the depressing passion of fear, and by the despair of accomplishing any important object; whereas, when urged to action and to enterprise, their energy is increased by hope, and by that presumption of their own superiority which all men readily entertain. Hence we have so few instances in history of nations successfully defended by rivers or extensive fortified lines; whereas mountainous countries have usually set bounds to the progress of armies. In such situations, the defending party can always act upon the offensive. He finds his adversaries divided, by their situation, into small parties. He hopes to vanquish them in detail, and he acquires strength and courage from the prospect of success.

While Bonaparte was advancing into the territory of the Pope, the Austrian army was arranging itself along the eastern bank of the Piava. The French were on the opposite bank, and Bonaparte hastened to join them after he had concluded his treaty with the Pope. The beginning of March was spent in preparations; but at last the troops advanced, that the point of resistance might be discovered. Having crossed the Piava on the 12th of March, the Austrians retired, skirmishing for some days till they had crossed the Tagliamento, where they made a stand with their whole force. Early on the 17th the French army arrived at Valvasone, on the opposite bank; and after some hesitation, resolved to force the passage of the river. To have accomplished this object very speedily would have been difficult, had not a recent frost diminished the stream, by which means the French were enabled to cross it in the face of the enemy in columns at various points. The army of Bonaparte was now in three divisions. Joubert, with the left wing, advanced along the course of the Adige into Tyrol, and was ordered to cross over from thence, and to descend along the valley of the river Drave, which is beyond the highest chain of what the Romans called the *Noric Alps*. Massena, with the centre, after crossing the Tagliamento, advanced into the defiles of these mountains; while the right division, which was attended by Bonaparte in person, proceeded along the coast of the Adriatic.

296 Progress of the French army.

French Revolution, 1797.

After forcing the paffage of the Tagliamento on the 17th, the French had eafily defeated the Auftrians on the oppofite bank, and compelled them everywhere to retreat. The other rivers were eafily paffed; and on the 19th, the town of Gradifca, on the river Lifonzo, furrendered to the right wing of the army, and its garrifon, amounting to 3000 men, were made prifoners of war. On the 21ft Goritz was entered by the fame divifion, who found there the principal Auftrian magazines and hofpitals. Triefte was entered on the 23d; and the French fent off in waggons, from the quickfilver mines of Ydria, materials worth 2,000,000 of livres. In the mean time, the Auftrians, in their hafty retreat, entangled themfelves and their baggage among the mountains. On the 24th, a large body of them was hemmed in between Maffena, who had reached Tarvis, and a part of the French right wing under Guieux. Reinforcements, however, having found means to reach them from the Archduke's head quarters at

297 The Auftrians defeated.

Clagenfurt, they hazarded an engagement on the following day, but were defeated, with the lofs of 5000 taken prifoners, and 400 waggons loaded with baggage. The French left wing under Joubert, Baraguay D'Hilliers, and Delmas, was equally fuccefsful. On the banks of the Lavis, after an obftinate engagement, 4000 Auftrians were taken; and thereafter at Clauzen they were again defeated, with the lofs of 1500 taken prifoners. Having entered Brixen, this divifion turned eaftward, and defcended the valley of the Drave towards Clagenfurt, the capital of Carinthia, where it was met by General Maffena; the Archduke, after a flight conteft, having evacuated the place, and advanced farther towards the capital of the empire, which was now

298 Wonderful fuccefs of Bonaparte.

ferioufly menaced, and in which great confternation prevailed. In 15 days Bonaparte had taken 20,000 prifoners, and croffed the Alps; and though the country ftill prefented fome difficulties, there was no fortified place capable of refifting his progrefs towards Vienna. He did not, however, confider his own fituation as deftitute of hazard, and feized the prefent moment of unbounded fuccefs to make propofals of peace. On the 31ft of March he fent a letter to the Archduke, in which he deprecated the ufelefs prolongation of the war, and intreated him to interpofe his good offices to put a ftop to its farther ravages. But this prince, who feems to have doubted his own influence at the court of Vienna, returned a cold anfwer, ftating, that it belonged not to him to inveftigate the principles on which the war was carried on, and that he had no powers to negociate.

299 Partial fucceffes of the Auftrians.

The Auftrian chiefs made a laft effort, by raifing the peafants of the Tyrol in a mafs to embarrafs the rear of the French. They accordingly gained fome fucceffes under General Laudohn, and drove out the French troops that had been left at Botzen and Brixen. The inhabitants of the Venetian ftates alfo rofe againft the troops that remained in their country; and being joined by ten regiments of Sclavonians, which had been in the pay of the government of Venice, they put the French to death wherever they were found, without excepting the fick in the hofpitals, of whom 500 were maffacred at Verona. A party of Imperialifts alfo drove the French garrifon out of Triefte, and thus attempted to furround the invading army. Bonaparte, however, knew that the court of Vienna muft be at leaft as much embarraffed as himfelf. His army amounted to 95,000 men. It had hitherto proved irrefiftible; and the Auftrians knew, that to furround was not to conquer it. He therefore perfifted in advancing. On the 2d of April he fucceeded in forcing the ftrong defiles between Freifach and Newmark, after a bloody battle, in which he took 600 prifoners. On the 4th, his advanced guard reached Hunfmark, where the Auftrians were again defeated; and his army occupied Kintenfeld, Murau, and Judenbourg. Thefe advantages compelled the Auftrian cabinet to treat for peace, as there was no longer any point at which the Archduke's army could hope to make a ftand till it came to the mountains in the vicinity of Vienna. Measures were taken for removing the public treafure and effects into Hungary, while Generals Bellegarde and Morveld were fent to requeft from Bonaparte a fufpenfion of hoftilities. On being fuffered to take poffeffion of Gratz and Leoben, within little more than 50 miles of Vienna, he confented, on the 7th of April, to an armiftice, which was only to endure till the night of the 13th, but was afterwards renewed for a longer period. It was followed on the 19th by a preliminary treaty, figned at Leoben; by which it was agreed that the Auftrian Netherlands fhould belong to France, and that the new republic in Lombardy fhould continue under the name of the *Cifalpine Republic*, and fhould include the Milanefe, the duchy of Mantua, and the territories of Modena, Ferrara, and Bologna. There is reafon to fufpect that fomething hoftile to [illegible] nice was here [illegible] withdraw without delay into [illegible] fiftence for his army during [illegible] folved, that all farther [illegible] fettled by a definitive treaty of peace. [illegible] he accufed the Venetian government [illegible] the infurrection which had taken place [illegible] in his abfence; and having feized [illegible] territory, he diffolved [illegible] now feeble, [illegible]

300 The Auftrian cabinet treats for peace.

While Bonaparte [illegible] French armies on the Rhine [illegible] the Auftrians, to prevent [illegible] from being fent againft him from that [illegible] The Auftrians offered an armiftice; but as the French demanded the fortrefs of Ehrenbreitftein as the price of it, both parties prepared for action. The left wing of the army of General Hoche advanced rapidly from Duffeldorf, while the centre and right wing croffed the Rhine near Coblentz. The Auftrians under General Wernecht retreated to the Lahn, where they waited the arrival of the French. Here a violent conteft enfued on the 18th of April, in which 4000 Auftrians were taken prifoners. The French took poffeffion of Wetzlaer, and drove their antagonifts to the gates of Francfort. In the mean time, General Moreau, on the Upper Rhine, forced the paffage of the river near Strafburg, and attacked the village of Dierfheim, of which he at laft retained poffeffion, after having been more than once driven out, and the village nearly deftroyed. The following day, however, the Auftrians renewed the attack, and forced the French for fome time to give way; but powerful reinforcements having croffed the river,

302 Succeffes of the French on the Rhine.

French Revolution, 1797.

river, the French were at last enabled to renew the battle with such vigour, that they took Fort Kehl, together with 5000 prisoners. The Imperialists in this quarter were now pursued towards the Danube; when all military operations were suddenly arrested by messengers sent through Germany by the Archduke Charles and Bonaparte, announcing that peace was concluded. These messengers found the army of Hoche violently attacking Francfort on the Maine, which General Wernecht was endeavouring to defend. The news was diffused in an instant through both armies; and the contending troops, throwing aside their weapons, congratulated each other upon the event.

303 Peace concluded.

304 Power of France at this period.

France now held a very elevated rank, and a formidable character, among the nations of Europe. Spain, Italy, and Holland, were held in dependence; while her victorious armies had compelled the last continental member of the coalition to accept of peace from an army that approached his capital. Had the Austrian officers been faithful, and the court of Vienna less selfish, subsequent events have indeed shewn that the affairs of the Emperor were not yet desperate, and that Bonaparte was not that invincible hero which his rapid successes gave some reason to suppose him. After the perusal of his letters from Egypt, his victories lose much of their brilliancy [illegible] all the actions of his life, [illegible] as the retreat of Moreau [illegible] when pressed on the rear by a victorious [illegible] surrounded on all hands [illegible] populace. But Bonaparte had been [illegible] knew not whom to trust: [illegible] that his plans were continually [illegible] council at home; and the [illegible] to make a peace. Of all [illegible] French revolution, Britain alone re[illegible]. From her command of the ocean [illegible] to retain the feeble state of Por[illegible] cause; but on land, such was the [illegible] that, with this exception, [illegible] by tolerance, the British [illegible] by her influence, from [illegible] from the Elbe to the A[illegible] British government was once more in[illegible] to try the effect of a new negociation. All these external advantages, however, were speedily lost by the French nation; and it seemed the unhappy destiny of this people to be constantly deprived of the fruits of all their sufferings, and their courage, by the turbulence of their domestic factions, and the profligacy and unprincipled conduct of their rulers.

306 Contest between the Directory and Councils.

A serious contest between the executive power and the legislature was now approaching. We already remarked, that the Directory was originally selected by those men who had been the associates of Robespierre; and though deserted of late by some of the more violent spirits, who were termed *Anarchists*, it was still considered as the head of the Mountain party. By the victory obtained over the sections of Paris on the 5th of October, all opposition had been set at defiance for a time; but the nation at large had never been reconciled to these men. The period now arrived when a third of the legislative body was to be changed. On the 19th of May, Letourneur went out of the directory by lot. On the 20th, the new third took their seats in the Councils, a third of their predecessors having evacuated their seats by lot; and on the following day, Barthelemi, the ambassador to Switzerland, was chosen to succeed Letourneur in the Directory. The election of the members of the new third had almost entirely fallen upon men who were understood to be hostile to the Directory. Many Generals out of employment were chosen; such as Pichegru, Jourdan, and Willot, and many representatives of the families of the ancient nobility who had not emigrated (among whom was the prince of Conti) were now elected into the legislature. The moderate or opposition party in the two Councils now possessed a complete majority. Carnot and Barthelemi were understood to be favourable to them in the Directory; the former having made his peace with them, and the latter being established by themselves. The effect of this change in the state of the Councils speedily appeared in their adopting every measure that could embarrass the Directory, or cast odium upon the Mountain party, and alter the state of things which it had established.

On the 14th of June, Gilbert Desmolieres brought forward a report from a committee upon the state of the finances; in which he exhibited and reprobated in the strongest terms the prodigality of the Directory, and the profusion and rapacity of its agents. On the 18th the same committee proposed a new plan of finance, the object of which was to deprive the Directory of any share in the administration of the public money. In the mean time, on the 17th of the same month, Camille Jourdan had presented a long report on the subject of religion; in which he endeavoured to demonstrate the impropriety of prohibiting the public display of its ceremonies, and the injustice of the persecution which its ministers had undergone for refusing to take oaths prescribed by the legislature. This report was afterwards, on the 15th of July, followed up in the Council of Five Hundred, by a decree, repealing all the laws against refractory priests, or which assimilated them to emigrants. On the following day, another decree, requiring from them a declaration of fidelity to the constitution, could only be carried by a majority of 210 against 204. A proposal was now brought forward in the Council of Five Hundred by Emery, a new member, to repeal the laws which confiscated the property of emigrants, and to allow their relations to succeed to them as if they had died at the period of their emigration. Those who had fled into foreign countries from Toulon and other places, during the reign of terror, were also encouraged to return, and allowed to expect that their names would be erazed from the list of emigrants. The conduct of the Directory towards foreign powers was attacked on different occasions; and Dumoullard proposed the appointment of a committee to enquire into the external relations of the republic. This was a delicate subject; as it involved the character of the armies and their leaders, and as it might subvert the interests of the Directory with some of their friends of the Mountain party. The Venetian republic, though a neutral state, had been overturned by Bonaparte on account of a popular insurrection, for which the government apologised. Little account had been given of the immense sums of money that had been levied in Italy. The armies in the preceding year had entered Germany in the character of

307 Mild measures of the Councils.

plunderers;

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plunderers; which had disgusted all those in that country who had once been friendly to their cause, and longed for their arrival. The Directory, at the same time, instead of encouraging the progress of revolution, which the Jacobins eagerly desired, had suddenly made peace with the German princes, upon receiving pecuniary contributions, which were left to be exacted according to the ancient laws of the different states (which exempt the nobles and the clergy), and thus fell heaviest upon those very persons who had cherished the new republican principles.

The discussion of these subjects brought the majority of the Directory and of the Councils into a state of complete hostility. Both parties resolved to violate the constitution, under the pretence of preserving it. The one wished to change the Directory before the time prescribed by law, and the other to deprive of their seats a great number of the new legislators elected by the people. Barras was the most obnoxious of the directors; and an attempt was made to deprive him of his office, upon the footing that he was less than 40 years of age. But his colleagues asserted that he was born in the year 1755; and as no proof to the contrary could be brought, this abortive attempt served only still farther to irritate the contending parties, and they began to prepare for more effectual measures. Had not force been speedily used on the side of the Directory, the Councils must naturally have prevailed.

308 Their popularity

The majority of the people confided in them. The national purse was in their hands; and they hoped to subdue the Directory, as the constituent assembly had done the king, by avoiding to vote the necessary supplies. They could enact what laws they pleased. They had not indeed the command of the armies; but to remedy their weakness in this respect, General Pichegru, on the 20th of July, presented a plan for reorganising the national guard, and placing it more at the disposal of the Councils by depriving the Directory of the nomination of the officers.

In the mean time the Directory was by no means destitute of adherents. The resolutions of the Councils in favour of the priests, and the relations of emigrants, looked so like a desertion of former maxims, that many persons expected an immediate counter-revolution. The royalists gained courage, and a multitude of journals or newspapers, favourable to their cause, began to be published. Emigrants obtained passports, and hastened to Paris in the hope of being struck off the list, upon alleging that they fled to avoid proscription during the power of the Jacobins. The effect of all this was, that the purchasers of national property, and those who had become rich by the revolution, were alarmed. The whole Mountain party, and all those who had been active in opposition to royalty, rallied round the Directory. The armies, whose chiefs found themselves involved in some of the accusations brought against that body, sent addresses, in which they declared their resolution to support its power. The Councils declared these addresses, which the Directory had received from armed bodies, unconstitutional, and procured counter addresses from different departments. At last the partizans of the two contending powers began to distinguish themselves in Paris by their dress, and every thing presaged an approaching appeal to force. On the 20th of July the Councils received intelligence that a division of the army of General Hoche had advanced within a few leagues of Paris; whereas, by the constitution, the Directory incurred the penalty of ten years imprisonment if it authorised troops to approach nearer to the residence of the legislative body than twelve leagues, without its own consent. An explanation of this event was immediately demanded. The Directory denied that they had ordered the march, and ascribed it to a mistake of the officer by whom it was conducted. Their explanation was treated with contempt, and much angry debate took place in the Councils concerning it; the Directory all the while conducting themselves with much seeming moderation, and even submissiveness. In the mean time their antagonists acted a very undecided part.

309 The Directory victorious.

They long hoped to gain Lareveillere Lepaux to their side; in which case they would have had a majority in the Directory. This vain expectation rendered their conduct indecisive. At length the majority of the Directory procured an address of adherence from the suburb St Antoine, which in all the tempestuous days of the revolution had been the rallying point of the Mountain party. Encouraged by this address they proceeded to immediate action. General Augereau had been sent from Italy under pretence of presenting some Austrian standards to the Directory, and he was employed as their tool upon this occasion. They commanded the garrison of Paris, and they had managed to bring over to their party the soldiers composing the guard of the two councils. Before day-break on the morning of the 4th, Augereau surrounded the Thuilleries with a division of the troops. The guard of the Councils refused to resist, and [illegible] was taken prisoner. Having [illegible] Pichegru and other twelve of the [illegible] party sitting in consultation, and [illegible] prisoners to the Temple. Some other [illegible] bers of the Councils were also put [illegible] director Carnot had made his escape [illegible] the [illegible] evening, but Barthelemi remained [illegible]

All this was accomplished [illegible] instant. Many members of the [illegible] came to the hall at the usual [illegible] find that seals were put upon the doors [illegible] could not obtain admittance. They were [illegible], however, to go to the Surgeons Hall and the theatre of the Odeon, where they were told the Directory had appointed the Councils to assemble. At these places, about forty of the Council of Ancients, and double that number of the other Council, assembled about noon, and sent to demand from the Directory an account of the proceedings of the morning. They received an answer, declaring, that what had been done was necessary to the salvation of the Republic, and congratulating the Councils *on their escape* from the machinations of royalists.

310 Pretended conspiracy

Being still at a loss how to act, the Council of Five Hundred appointed a committee of four members (of whom Sieyes was one) to report upon the measures to be adopted. On the following day Boullay de la Meurth presented a report from this committee, in which he announced, that a vast royalist conspiracy, whose centre was in the bosom of the Councils, had been formed to overturn the constitution, but that it had been baffled by the wisdom and activity of the Directory. The report concluded, by proposing the immediate transportation of the conspirators without a trial.

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trial. Accordingly, these degraded representative bodies proceeded, after some debate, on hearing the names of the accused persons read over, to vote the transportation to Guiana in South America, of fifty-three of their own members, and twelve other persons, among whom were the directors Carnot and Barthelemi. They annulled the elections in forty-nine departments, repealed the laws lately enacted in favour of the disaffected clergy and the relations of emigrants; and even so far abolished the liberty of the press, as to put all periodical publications under the inspection of the police for one year. New taxes were voted without hesitation, Francis de Neufchateau and Merlin were elected to fill the vacancies in the Directory, and affairs were endeavoured to be conducted in their ordinary train.

All this while the city of Paris remained tranquil. That turbulent capital, which had made so many sanguinary efforts in favour of what it accounted the cause of freedom, had been so completely subdued since its unfortunate struggle on the 5th of October, that it now permitted the national representation to be violated, and the most obvious rules of practical liberty to be infringed, without an effort in their defence. The Directory, in the mean time, attempted to justify their conduct to the nation at large, by publishing various documents intended to prove the existence of a royalist conspiracy. The most remarkable of these was a paper, said to be written by M. d'Antraigues, and found by Bonaparte at Venice; in which a detail [illegible] of a correspondence between General Piche- [illegible] of Condé in the year 1795. The [illegible] also, at the same time, said to [illegible] Moreau among papers taken by [illegible] passage of the Rhine. It stated, that [illegible] offered to the Prince of Condé to cross [illegible] with his army, and having joined the Au- [illegible] General Wurmser, and the emigrants un- [illegible] Condé, to return with the united ar- [illegible] Paris, where they were to re-establish [illegible] to have refused to accept of the [illegible] of the participation of the Austrians in [illegible] of the transaction. He therefore insisted that it should be conducted without their aid; but Pichegru thought the attempt too hazardous in this form, and, being soon after removed from his command, the project failed. At the time of its publication, the genuineness of this correspondence, and also of the paper found by Bonaparte, was denied; and nothing has appeared since to induce an unprejudiced man to think otherwise at present. Moreau, who was certainly involved in this conspiracy, if real, has been intrusted since that period with the command of the armies of the republic; and though defeated by Marshal Suwarrow, he is so far from being now considered as a royalist, that the revolutionary government seems inclined to intrust to his military skill and fidelity its last efforts for the continuance of its existence.

From the violation of the representative government that has been now stated, it became obvious to surrounding nations, that France had passed under the dominion of a small faction at variance with the majority of the people. The Directory was all powerful. Its members, however, seem very soon to have become giddy by the elevated nature of their situation, and to have adopted a notion that there was no project of ambition or rapacity in which they might not venture to engage. During their contest with the Councils, they had protracted the negociations with Lord Malmesbury at Lisle, and had suffered those to relax which had been entered into between Bonaparte and the Imperial ambassadors at Campo Formio near Udine. Great Britain had offered to consent to peace, on condition of being allowed to retain the Dutch settlement of the Cape of Good Hope, and the Spanish island of Trinidad, which had been taken in the month of February this year. The Directory now recalled their former negociators Letourneur and Maret, and sent two others, Treilhard and Bonnier, in their stead; who immediately demanded whether Lord Malmesbury had full power to restore all the settlements taken from France and her allies during the war? Upon his Lordship's declining to answer such a question, because it implied an enquiry, not into his powers, which were in the usual form, but into his instructions, which would preclude all negociation, he was required to return home to procure more ample powers. The negociations with the Emperor, however, were now speedily brought to a conclusion. On the 17th of October, a definitive treaty was signed at Campo Formio. By it the Emperor gave up the Netherlands to France, the Milanese to the Cisalpine republic, and his territories in the Brisgaw to the Duke of Modena, as an indemnification for the loss of his duchy in Italy. The Emperor also consented that the French should possess the Venetian islands in the Levant of Corfu, Zante, Cephalonia, Santa Maura, Cerigo, and others. On the other hand, the French Republic consented that the Emperor should possess in full sovereignty the city of Venice, and its whole other territory, from the extremity of Dalmatia round the Adriatic as far as the Adige and the lake Garda. The Cisalpine Republic was to possess the remaining territory of Venice in this quarter, along with the city and duchy of Mantua, and the ecclesiastical states of Ferrara and Bologna.

Upon whatever principles the war might have hitherto been conducted, the terms of this treaty sufficiently demonstrated to all Europe, that its lesser states had no better reason to expect security from the house of Austria than from that of the new republic. This truth would have been still more evident, had the articles of a convention, which was signed by these parties at the same period at Campo Formio, been published to the world. Fearing, however, to alarm too much the Germanic body, these articles were kept secret, and the parties agreed to prevail with the German princes, at a congress to be opened at Rastadt, to consent, in consequence of an apparently fair negociation, to what France and Austria had determined should take place. By the secret convention or treaty now alluded to, it was stipulated, that the Rhine, including the fortress of Mentz, should be the boundary of the French Republic; that the princes, whose territories were alienated by this agreement, should be indemnified by the secularization of church lands in Germany; that the Stadtholder of Holland should be indemnified for the loss of his estates in that country, by receiving German territory; that the Emperor should receive the Archbishopric of Saltzburg, and the part of the circle of Bavaria situated between that archbishopric, the rivers Inn and Salzt, and the Tyrol; that the Imperial troops should immediately withdraw to the confines of the hereditary states be-

312 The Directory all powerful.

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yond Ulm; and if the Germanic body should refuse peace on the above terms, it was stipulated, that the Emperor should supply to it no more troops than his contingent as a co-estate amounted to, and that even these should not be employed in any fortified place.

These treaties were immediately begun to be put in execution. The Austrians left the Rhine, which enabled the French to surround the fortresses of Mentz and Ehrenbreitstein. Of the former, they speedily obtained possession; but the latter cost them a very tedious blockade, before the garrison, consisting of troops of the Palatinate, would agree to surrender. The Imperial troops, at the same time, entered Venice; the French having evacuated that city after carrying off or destroying its whole navy. The Cisalpine Republic was established, and Bonaparte left Italy; leaving, however, an army of 25,000 men to garrison Mantua, Brescia, Milan, and other places, and to retain this new republic in dependence upon France. Genoa was, at the same time, brought under a similar dependence by means of popular commotions, instigated by the French, and a revolution in its government which took place at this period. And thus the French Directory, without the excuse of hostility, as in the cases of Holland and Spain, began a system of interference in the affairs of weaker neighbouring states, which was speedily carried to an height that once more alarmed all Europe. These men even attempted, at this time, to compel the states of North America to purchase with money their forbearance from war. This was done through a circuitous channel, and in the form of an intrigue, by private persons, who were instructed to inform the American ministers at Paris, that a large loan on the part of America would be the best means of securing peace; and it was hinted, that it would be rendered more acceptable if accompanied with a private present of L. 50,000 sterling to the members of the Directory. This last proposal was indeed denied by the French minister Tallyrand, who had given his countenance to this crooked negociation: but the general impression produced by the transaction could not be removed; and its effect was to injure very deeply the character of the French government in the opinion of those distant nations that were otherwise disposed to regard it in the most favourable light. Nor was its respectability increased by a law which the two Councils, at the desire of the Directory, thought fit to enact, declaring the ships of all neutral states bound for Britain, or returning from thence, liable to capture. This law was not less impolitic than unjust. It placed the whole carrying trade of the western world in the hands of the British, and thus enriched the very people whom it was intended to injure.

313 Violent measures of the Directory.

For at this period Britain had acquired over the ocean a degree of uncontrouled dominion that was altogether unexampled in former times. During the whole year the French fleet lay blockaded in its own ports, and no enterprise was attempted by sea, excepting in one solitary but singular instance. We have already mentioned that a number of galley slaves were sent as soldiers with Hoche in his attempt upon Ireland. On the failure of that expedition, the Directory were at a loss how to dispose of these men. They could not now with propriety be sent back to punishment, the troops would not serve along with them in the army; and as the new laws of France allow no remission of crimes, they could not receive a pardon, nor was it safe to let loose upon the country 1400 criminals. In this dilemma, the Directory resolved to throw them into England. Accordingly, they were sent in two frigates and some small vessels to the coast of Wales, and there landed with muskets and ammunition, but without artillery. In the evening of the very day on which they landed, the 23d of February, they surrendered themselves prisoners of war to a party of militia, yeomanry, cavalry, colliers and others, under the command of Lord Cawdor. The Directory boasted that, by this enterprise, they had demonstrated the possibility of landing troops on the British coast in spite of the vigilance of the navy; but this assertion was ill supported by the fate of the two frigates accompanying the expedition; both were captured in attempting to return to Brest.

314 Invasion of Wales.

Though the French navy remained in port, and consequently safe during the rest of the year, their allies, the Spaniards and Dutch, suffered severely. On the 14th of February, a British fleet of 15 sail of the line, under the command of Sir John Jervis, engaged the Spanish fleet, amounting to 27 sail of the line, off Cape St Vincent. In this action, the Spanish force, if it be estimated by the number of men, the number of guns, and the weight of metal, was more than double that of the British; but by the skilful manœuvres of its heroic commander, the British fleet twice crossed through the line of the Spaniards, and succeeded in cutting off a part of their fleet from the rest. Four ships of the line were taken, and the Spanish admiral's own ship [illegible] difficulty. The fleet had been [illegible] join the French fleet there; but [illegible] action, it returned to Cadiz, where it was [illegible] the British.

315 Brilliant victory of Sir John Jervis over the Spanish fleet,

For his gallant conduct in this engagement, [illegible] when every circumstance is taken into consideration, is perhaps unparalleled in the annals of naval [illegible] John Jervis was immediately created [illegible] and received the thanks of both [illegible] Parliament.

The Dutch were still more unfortunate. The Texel, within which their fleet lay, was blockaded during the whole summer by Admiral Duncan. The French intended, by means of the Dutch fleet, to make another attempt upon Ireland. Troops were accordingly embarked, under the command of General Daendels; but a resolution having at last been adopted of hazarding an engagement with the British, the Dutch admiral De Winter, in opposition to his own remonstrances, was ordered to put to sea. The British admiral had by this time left his station near the Texel, and gone to Yarmouth to refit. On receiving intelligence, however, that the Dutch had sailed, he instantly proceeded in quest of them. On the 11th of October the British fleet, amounting to 16 sail of the line, and 3 frigates, came in sight of the Dutch fleet, which in force was nearly equal, within about nine miles of Camperdown in Holland. Admiral Duncan immediately run his fleet through the Dutch line, and, though on a lee shore, began the engagement between them and their own coast. A most bloody and obstinate conflict ensued, which lasted nearly three hours. By that time, it is said that almost the whole Dutch fleet had struck. The ships could not all be approached and seized, however.

316 And of Admiral Duncan over the Dutch.

French Revolution, 1798. ever, on account of the shallowness of the water upon the coast, to which the fleets were now very near. Eight ships of the line, with two of 56 guns, and one of 44, were taken, besides a frigate, which was afterwards lost near the British coast, and one of the ships of 56 guns foundered at sea. Admiral de Winter was taken with his ship, and also the Vice-admiral Rentjies.

Similar honours were conferred upon Admiral Duncan as upon Sir John Jervis, and both admirals had each a pension of L. 2000 *per annum* conferred upon him for life, with the full approbation, we may venture to say, of every well-affected man in the kingdom.

1798. 317 Decline of public spirit in France. The internal history of France now ceased to be very interesting. Political freedom could not be said to exist after so many of the representatives chosen by the people had been driven from the legislature, and the departments reduced to the necessity of electing men more acceptable to their present rulers. Public spirit therefore rapidly declined. The high notions of the freedom and felicity it was about to enjoy, which had once been so eagerly cherished by a great part of the nation, now gave way to a growing indifference about political questions, and the future destiny of the republic; for the people at large found themselves little interested in a government which existed independent of their will, which consisted of a narrow circle of persons, and whose conduct was surely not less crooked, intriguing, and unprincipled, than that of the ancient royalty, and its attending court, from which they had escaped; whilst its ferocious cruelty, and total disregard even of the [illegible] were infinitely greater. But though [illegible] all-powerful, yet its power was limited [illegible] state of things, which denied it [illegible] of an abundant revenue. It had not yet [illegible] possible to re-establish a system of produc[illegible]. The legislative councils, indeed, who [illegible] with every wish of the Directory, voted [illegible], but these were scantily paid; part[illegible] total loss of the national com[illegible] the people were not disposed to [illegible] in this way for the support of go[illegible]. By the constitution, they still possessed the [illegible] of the judges and other magistrates; the country was filled with veteran soldiers, who at different times had returned from the armies after the lapse of

318 Measure of the Directory. the usual period of service. The Directory, kept in awe by these circumstances, turned its attention abroad, and found means to establish an extensive patronage, by dividing among its adherents the plunder of neighbouring states, in whose welfare the people of France were little interested. The Girondist party had formerly proposed to propagate their principles by establishing a number of petty republics in the vicinity of France. The Directory now adopted the same project; that, under the pretence of diffusing liberty, they might obtain new sources of revenue and of power, by the dominion which they meant to exercise over these new governments. Holland and the Cisalpine republic were already placed in dependence upon them; and Rome and Switzerland readily afforded them opportunities for extending their plan.

319 Embassy to Rome. After the treaty with the Emperor had been concluded at Campo Formio, Joseph Bonaparte, brother of the General, had entered Rome as ambassador from the French Republic. The Pope, now deprived of all hope of foreign aid, and accustomed to humiliations, had submitted to every demand made by him for reducing the number of his troops, and setting at liberty persons imprisoned on account of political opinions. But an event soon occurred to afford the Directory a pretence for accomplishing the ruin of this decayed government. On the 26th of December 1797, three persons had waited upon the French ambassador, and solicited the protection of his government to a revolution which a party at Rome meant to accomplish. He rejected their proposals, and dissuaded them from the attempt; but did not, as was certainly his duty, communicate these proposals to the papal government, to which he was sent on a friendly embassy. On the following day, however, a tumult took place, in which the French cockade was worn by about 100 insurgents. They were speedily dispersed, but two of the Pope's dragoons were killed. The ambassador, who probably knew the disposition of the Directory towards the Pope, seems to have resolved that his own personal conduct should be blameless on the occasion. He therefore went on the 28th of December to the secretary of state, and presented a list of the persons under his protection who were entitled to wear the French cockade, consenting that all others adopting it should be punished. He also agreed to surrender six of the insurgents who had taken refuge in his palace. Towards the evening of this day, however, the popular tumult became more serious, particularly in the courts and neighbourhood of the French minister's palace. The Pope appears to have been personally unacquainted with the state of affairs; but the governor of the city sent parties of cavalry and infantry to disperse the insurgents. About twenty persons, having a Frenchman at their head, had, in the mean time, rushed into the palace, and demanded aid towards accomplishing a revolution. A number of French officers, and others who were with the ambassador, proposed to drive the whole insurgents by force from the jurisdiction of the palace. This was certainly a salutary advice, and such as could not have been rejected by the ambassador, had not his designs been hostile to the established government. Rejected, however, it was; for, pretending to believe that his authority would be sufficient to accomplish the object in a peaceable manner, he went out into the court to address the multitude. He was prevented from doing so by a discharge of musquetry from the military, who were firing within the jurisdiction of the palace. He interposed with his friends between the military and the insurgents; and while a part of the French officers in his train drove back the insurgents with their sabres, the ambassador advanced towards the soldiers, and demanded why they presumed to violate his jurisdiction? as if the jurisdiction of a foreign ambassador were a legal asylum for men in open rebellion against the government of the state. It is not, therefore, surprising, that no attention was paid to this arrogant and absurd demand; and the nature of the ground being such, that the troops could fire over his head upon the multitude in the rear, they made a second discharge, which killed several of the insurgents. Upon this the ambassador advanced close upon the soldiers, to prevail with them to depart; but they remained in a menacing attitude, and prepared for another discharge. Eager to prevent this, the French General Duphot, who was with the ambas-

French Revolution, 1798. 320 Insurrection in that city.

French Revolution 1798.

ambaſſador, and was next day to have married his ſiſter, ruſhed into the ranks of the military, intreating them to deſiſt. Here a petty officer of the Pope's troops

321 A French general killed.

diſcharged his muſket into the body of Duphot. Upon this, the ambaſſador and his other friends found it neceſſary to make their eſcape through a bye-way into the palace. The Spaniſh miniſter hearing of this event, ſent to the ſecretary of ſtate to proteſt againſt this violation of the privileges of ambaſſadors. But the government, equally alarmed and perplexed by the fear of a revolution, and of French vengeance, remained during many hours totally inactive. All this while the palace of the French ambaſſador remained cloſely beſet by the military, who occupied the whole of its juriſdiction, and all its courts and paſſages. He at laſt ſent to demand paſſports, to enable him to leave the territories of the Pope. They were granted; but with many proteſtations of the innocence of the government, and its regret on account of this unfortunate occurrence.

Joſeph Bonaparte retired to Florence, and from thence to Paris. The Pope ſolicited the protection of the courts of Vienna, Naples, Tuſcany, and Spain; but they all ſtood aloof from his misfortunes: and this government, which had once poſſeſſed the moſt uncontrouled dominion over the minds of men, now fell without a ſtruggle. General Berthier, at the head of a body of French and Ciſalpine troops, encountered no

322 The papal government overturned.

oppoſition in his march to Rome, where he overturned the government of the Pope, and proclaimed the ſovereignty of the Roman people, with circumſtances of wanton inſult; which convey a ſtriking example of French humanity and French delicacy.

"That the head of the church might be made to feel with more poignancy his humiliating ſituation, the day choſen for planting the tree of liberty on the Capitol was the anniverſary of his election to the ſovereignty. Whilſt he was, according to cuſtom, in the Siſtine chapel celebrating his acceſſion to the papal chair, and receiving the congratulations of the cardinals, Citizen Haller, the commiſſary general, and Cervoni, who then commanded the French troops within the city, gratified themſelves in a peculiar triumph over this unfortunate potentate. During that ceremony they both entered the chapel, and Haller announced to the ſovereign Pontiff on his throne, that his reign was at an end.

"The poor old man ſeemed ſhocked at the abruptneſs of this unexpected notice, but ſoon recovered himſelf with becoming fortitude; and when General Cervoni, adding ridicule to oppreſſion, preſented him the national cockade, he rejected it with a dignity that ſhewed he was ſtill ſuperior to his misfortunes. At the ſame time that his Holineſs received this notice of the diſſolution of his power, his Swiſs guards were diſmiſſed, and republican ſoldiers put in their place." — 323 Cruel treatment of the Pope.

He was himſelf removed to the territory of Tuſcany, where he reſided in much obſcurity, till his enemies, driven from Rome in their turn, thought fit to carry him ſtill farther from his capital, to end his days beyond the Alps.

In the mean time, the Roman ſtates were converted into a republic after the French model; excepting that the ancient appellations of *conſuls, ſenators*, and *tri*[illegible] were adopted, inſtead of the new [illegible] and *two Councils* (D). But this [illegible] freedom was rendered completely [illegible] — 324 Roman re-

(D) The character of a nation, like that of an individual, will not perhaps admit of a ſudden and total ch[illegible] This remark is exemplified in the French; who, even when they affect to aſſume the ſtern manners of R[illegible] cans, cannot diveſt themſelves of their frivolous and fantaſtical turn, and of that fondneſs for [illegible] which they were always diſtinguiſhed. The following account of the re-eſtabliſhment of th[illegible] by an author of reſpectability, who witneſſed the ſolemn farce, will amply confirm the truth [illegible]

"That the regenerated Roman people might be conſtitutionally confirmed in their [illegible] day was ſet apart ſolemnly to renounce their old government, and ſwear fidelity to the new. For the [illegible]tion of this ſolemnity, which took place on the 20th of March, an altar was erected, in the middle of the piazza of St Peter's, with three ſtatues upon it, repreſenting the French, Ciſalpine, and Roman Republics. Behind the altar was a large tent, covered and decorated with ſilk of the Roman colours, ſurmounted with a red cap, to receive the deputies from the departments who had been ſummoned to aſſiſt. Before the altar was placed an open orcheſtra, filled with the ſame band that had before been employed to celebrate the funeral honours of Duphot. At the foot of the bridge of St Angelo, in the piazza di Ponte, was erected a triumphal arch, upon the general deſign of that of Conſtantine, in the Campo Vacino, on the top of which was alſo placed three coloſſal figures, repreſenting the three republics. As a ſubſtitute for baſs-reliefs, it was painted in compartments in *chiara ſcura*, repreſenting the moſt diſtinguiſhed actions of Bonaparte in Italy. Before this arch was another orcheſtra.

"The ceremony in the piazza began by the marching in of the Roman legion, which was drawn up cloſe to the colonnade, forming a ſemicircular line; then came French infantry, and then cavalry, one regiment after another alternately, drawn up in ſeparate detachments round the piazza. When all was thus in order, the conſuls made their entrance, on foot, from the Vatican palace, where they had robed themſelves, preceded by a company of national troops and a band of muſic; and if the weather had permitted, a proceſſion of citizens, ſelected and dreſſed in *gala* for the occaſion, from the age of five years to fifty, were to have walked two and two carrying olive branches; but an exceſſively heavy rain prevented this part of the ceremony.

"Before the high altar, on which were placed the ſtatues, there was another ſmaller one with fire upon it. Over this fire the conſuls, ſtretching out their hands, ſwore eternal hatred to monarchies, and fidelity to the republic; and at the concluſion, one of them committed to the flames a ſcroll of paper he held in his hand, containing a repreſentation of all the inſignia of royalty, as a crown, a ſceptre, a tiara, &c.; after which the French troops fired a round of muſketry; and, at a ſignal given, the Roman legion raiſed their hats in the air upon the points of their bayonets, as a demonſtration of attachment to the new government: but there was no ſhouting—

French Revolution, 1798.

tion annexed to it, that for ten years the French General should possess a negative upon all laws and public acts. At first, however, the conquerors took care to place the government in the hands of the most respectable persons in the state favourable to democracy. But these men finding that they were merely to be employed as tools to plunder their fellow-citizens, for the emolument of their northern masters, soon renounced their odious dignities, and were succeeded by men of more compliant characters, and less scrupulous integrity. The whole public property was seized by the invaders, and contributions were levied without end. The property of the cardinals and others who fled was confiscated, and those members of the sacred college who remained were thrown into prisons, from which they could only escape by purchasing their freedom at a high price.

When this was done, and Generals and Commissaries had glutted themselves with wealth, quarrelled about a *just* division of the spoil, mutinied, and dispersed, other unpaid, unclothed, unprovisioned armies from the north, with new appointments, succeeded; and when at length, even by these *constitutional* means, nothing more was to be obtained, and artifice had exhausted every resource, the mask was put under the feet that had been long held in the hand; liberty was declared dangerous to the safety of the republic, the constituted authorities in-
325 Superseded by military despotism. capable of managing the affairs of the state, and military law the only rational expedient to supply their place. Thus at once the mockery of consular dignity was put an end to, the senators sent home to take care [illegible] and the tribunes to blend with the peo[illegible] represented. This new and pre[illegible] began its operations with nothing less [illegible] for the general welfare, than seizing the whole annual revenue of every estate productive of more [illegible] thousand crowns; two-thirds of every estate [illegible] more than five, but less than ten; and [illegible] of every inferior annual income.

[illegible] degenerated Romans could not have sub[illegible], or at least would not have assisted in forging their own chains, had not the same means been employed to eradicate from their minds every moral and religious principle, which had been formerly employed for the same purpose in Paris. In order that the spirit of equality might be more extensively diffused, a constitutional democratic club was instituted, and held in the hall of the Duke d'Altemp's palace. Here the new-born sons of freedom harangued each other on the blessings of emancipation; talked loudly and boldly against all constituted authority; and even their own consuls, when hardly invested with their robes, became the subjects of censure and abuse. The English were held as particularly odious, and a constant theme of imprecation; and this farce was so ridiculously carried on, that a twopenny subscription was set on foot to reduce what they were pleased to call the proud Carthage of the North.

French Revolution, 1798.

326 Methods employed to corrupt the Roman youth.

If this foolish society had had no other object in view than spouting for each other's amusement, bowing to and kissing a bust of Brutus which was placed before the rostrum (a ceremony constantly practised before the evening's debate), it would have been of little consequence to any but the idle, who preferred that mode of spending their time; but it had other objects of a very different tendency, more baneful, and more destructive to the peace and morals of society—that of intoxicating young minds with heterogeneous principles they could not understand, in order to supersede the first laws of nature in all the social duties; for there were not wanting men who knew how to direct the folly and enthusiasm of those who did not know how to direct themselves. Here they were taught, that their duty to the Republic ought ever to be paramount to every other obligation; that the illustrious Brutus, whose bust they had before them, and whose patriotic virtue and justice ought never to be lost sight of, furnished them with the strongest and most heroic example of the subordination of the dearest ties of humanity to the public good; and that, however dear parental affection might be, yet, when put in competition with the general welfare of society, there ought not to be a moment's hesitation which was to be preferred.

This sort of reasoning might perhaps have done no harm to the speculative closet metaphysician, who might have had neither father, nor mother, nor brother, nor sister, nor a chance of ever being thrown in the way to reduce his theory to practice; but with a people who knew of no other ties but such as depended on their religion and their natural feelings, without having been previously educated to discriminate, how far their reason might be deluded by sophistry, or upon what

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no voluntary signs of approbation; nor do I believe that there ever was a show, in which the people were intended to act so principal a part, where so decided a tacit disapprobation was given as on this occasion.

"After the ceremony was concluded, the French officers, with the consuls and deputies from the departments, dined together in the papal palace on Monte Cavallo, and in the evening gave a magnificent ball to the exnobles and others, their partizans, which was numerously attended, yet with an exception to the houses Borghese, Santacroce, Altemp, and Cesarini: I believe not one distinguished family was present from desire or inclination: but it was now no longer time to accumulate additional causes for oppression; and he who hoped to save a remnant of his property, avoided giving occasion for personal resentment. At night the dome of St Peter's was illuminated, with the same splendour as was customary on the anniversary of St Peter's day. This was the second time of its illumination since the arrival of the French, having been before displayed on the evening of the solemn fete to honour the manes of Duphot, which, though not quite so opportune, was done to gratify the officers that were to leave Rome on the morrow.

"The day after this federation, the French published the Roman constitution in form, which was only a repetition of the one given to the unfortunate Venetians, consisting of 372 articles, and which I think unnecessary to transcribe, as it would only be giving what we have already had from time to time in translations made from their own."—*Duppa's Journal of the most remarkable Occurrences that took place in Rome,* upon the Subversion of the Ecclesiastical Government in 1798.

French Revolution, 1798. causes the permanent good of society depended, it had the most direct tendency to generate the worst passions, and to annihilate the best.

Young men were thus initiated to lose all respect for their parents and relations, and even encouraged to lodge information against them, with the hopeful prospect of being considered as deserving well, of what they were pleased to denominate, the republic; and by thus weakening or destroying the bonds of affection, the way was made smooth and easy to the destruction of every thing like what, in a state of civilization, is called character; doubtless, in order to prepare them the better to become the faithful agents of those whom they were thus educated to serve.

317 Monuments of ancient art exposed to sale.

The most remarkable curiosities of this celebrated city had already been conveyed to Paris; and as national vanity had now given place to avarice in the minds of the Directory, the remaining monuments of ancient or of modern art, with which Rome abounded, were sold by public auction. Advertisements (ε) were sent through Europe, offering passports to the natives of countries at war with France, if they should wish to become purchasers; and thus the wealthier inhabitants of the Roman territory not only saw themselves subjected to severe exactions, but they beheld with cruel mortification those objects now given up as a prey to vulgar speculation, and dispersed over the world, which had so long rendered their city the resort of all nations.

Such was the progressive conduct of the *Great Nation* towards an injured and oppressed people, whose happiness and dearest interests were its first care, and to whom *freedom* and *liberty* had been restored, that they might know how to appreciate the virtue of their benefactors, and the inestimable blessings of independence.

318 French ingratitude to Switzerland.

More sanguinary scenes were, in the meanwhile, taking place in Switzerland. That country had remained neutral during the contest in which France had lately been engaged; and had thus protected the weakest portion of her frontier, while the rest of it was assailed by the combined forces of Europe. The merit of this service was now forgotten, and the Directory resolved to render Switzerland one of their tributary states. Ambitious nations have in all ages found it an easy matter to devise apologies for invading the territory of their neighbours. The wealthier branches of the Swiss confederacy were in general governed by hereditary aristocracies. Some of the cantons had no government within themselves, but were the subjects of neighbouring cantons. In consequence of this circumstance, and of the contending privileges of different orders of men, popular insurrections were more frequent in Switzerland than in any country in Europe, though none was more equitably governed. When an insurrection took place in one canton, its government was frequently under the necessity of soliciting the aid of the government of an adjoining canton, or even of the neighbouring monarchs of France or Sardinia, to enable it to subdue its own rebellious subjects. A dangerous precedent was thus established; and as the French kings had formerly interfered in favour of the rulers, the republican Directory now interfered in favour of the subjects. The canton of Berne was sovereign of the territory called the *Pays de Vaud*. In this district discontents had always existed; and an insurrection, under the countenance of the French Directory, broke out towards the end of the year 1797. The government of Berne saw the dangerous nature of its own situation; and on the 5th of January issued a proclamation, commanding the inhabitants of the Pays de Vaud to assemble in arms, to renew their oath of allegiance, and to reform every abuse that might appear to exist in their government. A commission was at the same time appointed by the Senate or Sovereign Council at Berne to examine all complaints, and to redress all grievances. The proceedings of this commission, however, did not keep pace with the popular impatience; and the insurgents began to seize the strong places in their country. The government of Berne now resolved to reduce them by force, and sent troops against them; but their commander Weiss appears to have acted with much hesitation, if not with treachery. In the mean time, a body of French approached under General Menard. He sent an aide-de-camp with two hussars, with a message to General Weiss. On the return of the messengers, an accidental affray took place, in which one of the hussars was killed. This was magnified into an [illegible] breach of the law of nations. The French [illegible] and by the end of January obtained [illegible] whole Pays de Vaud. Still, ho[illegible] of Berne attempted to preserve [illegible] voured to prepare for war. The soldiers [illegible] ed the French hussar were delivered up, [illegible] were begun, and a truce entered into with [illegible] Brune, who succeeded Menard in the command of the French troops in the Pays de Vaud. [illegible] motions were breaking out in all [illegible] was made to quiet the minds [illegible] might be induced to unite [illegible] sion. Fifty two deputies from the different districts were allowed to sit in the Supreme Council of Berne, and a similar measure was adopted by the cantons of Zurich, Lucerne, Fribourg, Soleure, and Schaffhausen. An army of 20,000 men was at the same time assembled, and intrusted to the command of M. d'Erlach, formerly field-marshal in the French service. But disaffection greatly prevailed in this army, and the people could not be brought to any tolerable degree of union. The French knew all this, and demanded a total change of government. M. d'Erlach, dreading the increasing tendency to desertion among his troops, requested leave to dissolve the armistice. It was granted by the government, and immediately recalled. But the French now refused to negociate; and on the 2d of March, General Schawenberg, at the head of 13,000 men, entered Soleure.

(ε) A copy of an advertisement, issued on this occasion by what was called *The Administration of Finances and Contributions of the French Republic in Italy*, is to be found in *Nicholson's Journal of Philosophy, Chemistry, and the Arts, for May* 1798. The advertisement is dated at Rome, 28th Feb. 1798. A copy of it was sent by Hubert, the agent of the French administrators, to Mr Trevor the British minister at Turin, and by him was transmitted to England.

French Revolution, 1798.

Soleure. Friburg was afterwards reduced by Brune, and the Swiss army retreated. The government of Berne was in consternation, and decreed what was called the *landsthurm*, or rising of the people; which, in cases of emergency, was authorised by their ancient customs.

330 Consternation of the government, and capitulation of Berne.

The people accordingly assembled; and their first act was to dissolve the government, and to offer to dismiss the army, on condition that the French troops should proceed no farther. This offer was refused, unless a French garrison should be received into Berne, and the invaders continued to advance. The regular troops under M. d'Erlach were reduced by desertion to 14,000. The rising of the people had indeed supplied him with numbers, but there was no time for arranging them. On the 5th of March he was attacked, and driven from the posts of Newenbeg and Favenbrun. He rallied his troops, however, at Uteren, where they made a stand for some time. They renewed the contest at Grauholtz without success, and were driven from thence about four miles farther to the gates of their capital. Here the Swiss army made a last and bloody effort. Being completely routed, they murdered many of their officers in despair, and among others their commander M. d'Erlach. The slaughter on both sides is said to have been nearly equal; but the French succeeded in obtaining possession of Berne by capitulation on the evening of the day on which these battles were fought. Upon the capture of this city, the other more wealthy and populous states submitted to the French; but the poorer cantons, who had least to lose, made a terrible [illegible] in defence of their small possessions, and the inde[illegible] country. They even at first com[illegible] to retire with the loss of 3000 [illegible] overpowered by the superior [illegible] military skill of the French army. Swit[illegible] was treated as a conquered country. Its pub[illegible] were seized by the French, heavy contri[illegible] were levied, and a new constitution, in imita[illegible] France, was imposed.

331 [illegible] land treated as a conquered country.

[illegible] continued to encroach upon [illegible] other nations, they were not likely [illegible] freedom of their countrymen at home. In [illegible] of April, a third of the legislature was changed. Francis de Neufchateau went out of the Directory by ballot, and Treilhard was chosen in his stead. The Directory had made great efforts to influence the elections in favour of their friends, but with little success. They prepared therefore to preserve the legislature in subjection to them by a new violation of the constitution. On the 2d of May they complained to the Council of Five Hundred of the plots of anarchists and royalists; by which they alleged that the elections had in many places been made to fall on men hostile to the Republic. On the 7th a committee made a report upon this message, and proposed that the proceedings of many electoral assemblies should be totally or partially annulled, according to the characters of the persons they had chosen. General Jourdan, and some others, ventured to oppose this plan as utterly inconsistent with the freedom of election, and as proceeding upon alleged intrigues of conspirators against the Republic, while no conspiracy had been proved to exist. But the majority agreed to the proposal of the committee, and arbitrarily annulled the whole elections in six or seven departments, besides the particular elections of a great number of individuals.

332 The Directory violates the constitution.

The Directory now carried into effect the most fatal of all their projects, that of sending a powerful army to the east to seize upon Egypt, and from thence to attack the empire which Britain has acquired in India. The treaty with Austria had no sooner been signed at Campo Formio, than the Directory excited the expectation of France and of all Europe, by loudly proclaiming their determination to invade Great Britain. They sent troops into their own western departments, called them the *Army of England*, and appointed Bonaparte their commander in chief. This officer, in the mean time, had resided during the winter at Paris. Here he seems to have endeavoured to guard against the jealousy of government, and the envy of individuals, by passing his time in retirement, and assuming the character of a man of letters. He procured himself to be elected a member of the National Institute; but so seldom did he appear abroad, that when he attended some of its public sittings his person was altogether unknown to the spectators. Greedy of renown, but aware that it ultimately depends upon the labours and the approbation of the learned, he never failed, when called into military service, to remind this order of men of his alliance with them, by adding to his name at all proclamations and dispatches the designation of *Member of the National Institute*.

French Revolution, 1798.

333 Project of an expedition to Egypt and India.

Whether the expedition to Egypt was now suggested by Bonaparte himself, or whether it was not a snare by which the present rulers of France imposed upon the vanity of an enterprising young man, to enable them to get quit of him and his veteran army, is not known. It is very possible, however, that Bonaparte might neither be the deviser nor the unconscious victim of this plan; but that he might account himself more safe abroad, upon the most hazardous expedition, than exposed at home to the malice of a government that had become jealous of his reputation, and was by no means scrupulous in its conduct.

The projected invasion of Egypt was conducted with much secrecy. The world was amused with tales of monstrous rafts to be constructed to convey the army of England over into Britain. To favour the deception, Bonaparte made a journey to the western coast. In the mean time, the fleet was preparing at Toulon, and troops assembling in its neighbourhood. When all was in readiness, Bonaparte embarked with 40,000 of the troops that had fought in Italy. On the 9th of June he arrived at the island of Malta, and contrived to quarrel with the Grandmaster, because he refused to admit so large a fleet all at once into his ports to water. The French General immediately landed his troops in different quarters, and endeavoured to reduce the island. The knights were divided into factions. Many of them, as is now well known, were of the order of ILLUMINATI, and of course prepared to act the part of traitors. After making a very feeble resistance, the Grandmaster proposed a capitulation; and thus was treacherously surrendered, in a few days, a fortress which, if defended by faithful troops, might have held out for as many weeks against all the forces of the French Republic. Bonaparte, after leaving a garrison of 4000 men in the island, sailed on the 21st of June for Alexandria.

334 Preparations for it conducted with secrecy.

335 Conquest of Malta.

In the mean time, Rear-admiral Nelson, who, in the station of Commodore, had signalized himself in a very high degree under Lord St Vincent, had been dispatched in quest of him from the British fleet, which still blockaded

336 Admiral Nelson fails in quest of Bonaparte.

French Revolution 1798

blockaded Cadiz. Not knowing the object of the French expedition, the British Admiral sailed first to Naples; and having there been informed of the attack upon Malta, he directed his course to that island. By the time he arrived there, however, Bonaparte had departed. Conjecturing now that Alexandria might be the destination of the French troops, he sailed thither; but they had not been seen in that quarter, and he therefore went eagerly in search of them to other parts of the Mediterranean. Bonaparte, in the mean while, instead of steering in a direct line for Alexandria, had proceeded slowly, with his immense train of nearly 400 transports, along the coast of Greece, till he arrived at the eastern extremity of the island of Candia. Here he suddenly turned southward; and in consequence of his circuitous course, did not arrive at the coast of Egypt till Admiral Nelson's fleet had left it. He landed his troops; and on the 5th of July took by storm the city of Alexandria. The inhabitants defended themselves very desperately, but without skill; and for some time a scene of barbarous pillage and massacre ensued. The transports that had conveyed the army were now placed within the inner harbour of Alexandria, and the ships of war under Admiral Brueys cast anchor in a line close

337 Conquests of Bonaparte in Egypt.

along the shore of what proved to them the fatal Bay of Aboukir. The army proceeded to the Nile, and ascended along the banks of that river, suffering great hardships from the heat of the climate. They were met and encountered by the Mamalukes, or military force that governed Egypt; but these barbarians could not resist the art and order of European war. Cairo was taken on the 23d of July. On the 25th another battle was fought; and on the 26th the Mamalukes made a last effort in the neighbourhood of the celebrated pyramids for the preservation of their empire. Two thousand of them were killed on this occasion, 400 camels laden with their baggage were taken, along with 50 pieces of cannon.

A provisional government was now established in Egypt. Proclamations were issued in the Arabian tongue, declaring that the French were friendly to the religion of Mahomet, that they acknowledged the authority of the Grand Signior, and had only come to punish the crimes committed by the Mamalukes against their countrymen trading to Egypt. Thus far all had gone well; but on the 1st of August the British fleet appeared at the mouth of the Nile; and the situation of the French fleet having been discovered, Admiral Nelson

338 Admiral Nelson attacks and destroys the French fleet.

prepared for an attack. In number of ships the fleets were equal; but in the number of guns and weight of metal the French squadron had the superiority. It was drawn up, too, in a form which suggested to its ill-fated commander the idea of its being invincible; but remaining at anchor, the British Admiral was enabled, by running some of his ships between those of the enemy and the shore, to surround and engage one part of their fleet, while the rest remained unemployed and of no service. In executing this plan of attack, a British ship, the Culloden, run aground; but this accident only served as a beacon to warn the others of the spot that ought to be avoided. The battle commenced at sunset, and was continued at intervals till daybreak. At last, nine sail of the French line were taken; one ship of the line was burned by her own commander; a frigate was burned in the same manner, to prevent her being taken. The French Admiral's ship L'Orient took fire, and blew up during the action, and only a small number of her crew of 1000 men escaped destruction. Two French ships of the line and two frigates were saved by a timely flight (F).

No naval engagement has in modern times produced such important consequences as this. 339 Consequences of his victory.
The unexampled military efforts made by France had gradually dissolved the combination which the princes of Europe formed against her. By the train of victories which Bonaparte had gained, the house of Austria, her most powerful rival, had been humbled and intimidated. The whole continent looked towards the new Republic with consternation; and when the Directory seized upon Rome and Switzerland, none were found hardy enough to interpose in their favour. The current of affairs was now almost instantaneously altered. Europe beheld Bonaparte, with his *invincible* army, exiled from its shores, and shut up in a barbarous country, from which the triumphant navy of Britain might for ever prevent his return. The enemies of France could not beforehand have conceived the possibility of the event which was now realised; and the hope was naturally excited of being able to form a new and more efficient coalition against a government which had so grossly abused the temporary prosperity it had enjoyed. The northern powers began to listen to the proposals made to them by Great Britain for commencing hostilities [illegible] the Italian states prepared to [illegible] independence. The court of Na[illegible] ly avowed its joy on account o[illegible] of the French fleet. The king [illegible] meet Admiral Nelson on his return [illegible] luminations took place in the capital, and vi[illegible] parations were made for war. The Grand S[illegible] had possessed of late little authority [illegible] perhaps have been induced to [illegible] that province rather than [illegible] war, now entered into close [illegible] engaged in hostilities against the French. [illegible] tan had stipulated for the aid of a French [illegible] the British in India; but Bonaparte, on [illegible] possession of Suez and the other Egyptian ports on the Red Sea, found no shipping there fit to transport his army to the Indian peninsula. Instead of proceeding therefore upon any splendid scheme of farther conquest, he was compelled to remain in his present situation, and to contend for existence against the whole force of the Ottoman empire.

The French at this time did not venture to send forth any large fleet upon the ocean; but wherever their smaller squadrons appeared, the fortune of Britain overpowered them there no less than it had done in the Mediterranean. 340 Rebellion in Ireland.
They had long promised aid to the disaffected party in Ireland; but weary of fruitless expectation, the Irish had during this summer broken out into rebellion, without waiting the arrival of the troops whom the Directory had engaged to send to their assistance. While the rebellion was at its height, and although the insurgents for some time occupied the sea port of Wexford, the French did not arrive. Afterwards,

(F) The two ships of the line and one of the frigates have been since taken.

French Revolution. 1798.

wards, however, when the rebellion had been totally subdued, they attempted to elude the vigilance of the British fleet, and to land men in small parties. On the 22d of August, General Humbert came ashore at Killala, at the head of about 1100 men. Even this small party might have been dangerous had it arrived a month earlier; and it actually produced very serious alarm. It consisted of men selected with great care, and capable of enduring much fatigue. They were joined by a few of the most resolute of the discontented Irish in the neighbourhood, and speedily defeated General Lake, who advanced against them with a superior force, taking from him six pieces of cannon. They next marched in different directions, for the purpose of raising the people, and maintained their ground in the country during three weeks. Finding, however, that he was not seconded by additional troops from France, that the rebellion in Ireland had been fully subdued, and that 25,000 men under Lord Cornwallis were closing round him, Humbert dismissed his Irish associates; and four days thereafter, having encountered one of the British columns in his march, he laid down his arms. Now, when it was too late, the Directory was very active in sending troops towards Ireland; but all their efforts were defeated by the superiority of the British navy.

341 *Feebly supported by the Directory.*

342 *Whose efforts are defeated by the British navy.*

On the 12th of October, Sir John Borlase Warren took La Hoche, a ship of 84 guns, and four frigates, attempting to reach Ireland with nearly 3000 men on board. The other ships belonging to the French squadron, which conveyed 5000 men in all, contrived to [illegible] by sailing round by the north of the [illegible] 20th of the same month another fri[illegible] Ireland was taken; and the French [illegible] was completely occupied by the [illegible] at last compelled to desist from their [illegible]

[illegible] the treaty of Campo Formio had been [illegible] a congress of ministers from the French Di[illegible] German princes, had been nego[illegible] treaty between France and the em[illegible] negociations terminated in nothing, [illegible] and uninteresting during their pro[illegible] unnecessary to enter into a detail of the steps by which they were conducted. The intended result of them had been previously arranged between the Emperor and the Directory in the secret convention of Campo Formio, which has been already mentioned.

343 *Negociations at Rastadt.*

That the articles of this convention might be concealed, the French ministers at Rastadt formally brought forward their proposals in succession for the discussion of the German deputies. The French demanded that the Rhine should be the boundary of their Republic. The Germans resisted this. References were made to the diet of Ratisbone, and long discussions and negociations took place among the different princes. When it was found that little was to be expected from the protection of Austria, the German deputies at Rastadt were instructed to offer one half of the territory demanded. This offer was refused, and new negociations took place. The other half was at last yielded up, and a long discussion commenced about the debts due by the ceded territory, which the French refused to pay. The tolls upon the river, and upon the rivers flowing into the Rhine, also gave rise to much altercation. It was even a matter of no small difficulty, after all, to determine the precise boundary of France; whether her territory should extend to the left bank, the right bank, or the thalweg, that is, the middle of the navigable channel of the river. It became also a question how those princes ought to be indemnified who lost their revenues or territories by the new acquisitions of France; and it was at length agreed that they should receive portions of the ecclesiastical estates in Germany.

These discussions, conducted with endless formality and procrastination, still occupied the congress at Rastadt; but it now became gradually more probable that no treaty would be concluded at that place. Austria began to strengthen her armies in all quarters. Russia, that had hitherto avoided any active interference in the contest, placed a large body of troops in British pay, and sent them towards the German frontiers. The king of Naples avowedly and eagerly prepared for war. This impatient monarch, resolving to attack without delay the French troops who occupied the Roman territory, procured General Mack and other officers from the court of Vienna to assume the command of his army. Without waiting, however, till Austria should commence the attack, he rashly began the war alone and unaided, excepting by the British fleet, and thus drew upon himself the whole force of the French Republic. The Directory did not suspect such imprudent conduct on the part of this prince; and accordingly, when General Mack entered the Roman territory, at the head of 45,000 men, the French troops in that quarter were altogether unequal to the contest. A French ambassador still resided at Naples when this event took place, and war was not declared. When the French General Championnet complained of the attack made upon his posts under these circumstances, he was informed in a letter by General Mack, that the king of Naples had resolved to take possession of the Roman territory, having never acknowledged its existence as a Republic; he therefore required the French quietly to depart into the Cisalpine states; declaring, that any act of hostility on their part, or their entrance into the territory of Tuscany, would be regarded as a declaration of war.

344 *Preparations for war on the Continent.*

Championnet finding himself unable to resist the force now brought against him, actually evacuated Rome. He left, however, a garrison in the castle of St Angelo, and endeavoured to concentrate whatever troops he could hastily collect in the northern extremity of the Roman state. Towards the end of November, General Mack entered Rome without opposition.

345 *The Neapolitans take possession of Rome.*

When these events came to be known at Paris, war was immediately declared against the king of Naples, and also against the king of Sardinia. This last prince had made no attack upon France; but he was accused by the Directory, in their message to the Councils, of *disaffection* to the Republic, and of *wishing* to join the king of Naples in his hostile efforts. This accusation could not well be false. From the period of Bonaparte's successful irruption into Italy, the king of Sardinia had felt himself placed in the most humiliating circumstances; his most important fortresses were occupied by the French; they levied in his country what contributions they thought fit; and when they recently required him to receive a garrison into his capital, he found himself unable to resist the demand. Even now, when they performed the useless ceremony of declaring war, he could make no effort in his own defence, and quietly

346 *Hard fate of the king of Sardinia.*

French Revolution 1798.

quietly gave them a formal reſignation in writing of his whole continental dominions, conſenting to retire to the iſland of Sardinia.

In the mean time, the conteſt with Naples was ſoon decided. The French on their retreat were much haraſſed by the people of the country. The Neapolitan troops regarded them with ſuch animoſity, that they ſcarcely obſerved the modern rules of war towards the priſoners who fell into their hands. Even their leaders ſeemed in this reſpect to have forgotten the practice of nations; for when General Bouchard, by order of General Mack, ſummoned the caſtle of St Angelo to ſurrender, he declared, that he would conſider the priſoners of war and the ſick in the hoſpitals as hoſtages for the conduct of the garriſon; and that for every gun that ſhould be fired from the caſtle, a man ſhould be put to death. It cannot well be imagined that the Neapolitan officers would have acted in this vehement manner, had they not expected countenance and ſupport from the immediate co-operation of Auſtrian troops.

347 Naples conquered by the French.

In their hopes from this quarter, however, they were completely diſappointed. Mindful of her recent calamities, and attentive only to her own aggrandiſement, Auſtria ſeems ſtill to have expected more from negociation than from war, and the territory of Naples ſoon fell into the hands of the French. Such indeed was the terror of the French name in Italy, or ſuch was the diſaffection or cowardice of the Neapolitan troops themſelves, that they were beaten by one-fourth of their number in different engagements, at Terni, Porto Fermo, Civita Caſtellana, Otricoli, and Calvi. At the commencement of the conteſt, a body of Neapolitans, with the aſſiſtance of the Britiſh fleet, had been landed at Leghorn, for the purpoſe of taking the French in the rear: but they, diſregarding this attempt on the part of ſuch an enemy, preſſed on towards Naples. By degrees, General Mack's army being reduced by the reſult of the battles which it fought, and by deſertion, to 12,000 men, he found it neceſſary to adviſe the king and royal family of Naples to take refuge on board the Britiſh fleet. They did ſo; and arrived at Palermo, in Sicily, on the 27th of December, in the Britiſh Admiral Lord Nelſon's ſhip. General Mack, in the mean time, requeſted an armiſtice, to afford an opportunity for making peace; but this was refuſed. Being driven from Capua, which is the laſt military poſt of any ſtrength in the Neapolitan territory, and his life being in no ſmall danger from the diſaffection of his own troops, he at laſt found it neceſſary to ſeek for ſafety, by ſurrendering himſelf, along with the officers of his ſtaff, to the French General. The governor of Naples, in the mean time, offered to the French a contribution in money, if the commander in chief would conſent to avoid entering that city. The offer was accepted, and the invading army remained at Capua. General Serrurier, on the 28th of December, at the head of a column of French troops, expelled the Neapolitans from Leghorn, and took poſſeſſion of that place. So far as the efforts of regular armies are to be conſidered, the war might now therefore be regarded as brought to a termination; but the French had ſpeedily a new and unuſual enemy to contend againſt.

1799.

From the mildneſs of the climate, and the fertility of the ſoil, human life can be ſuſtained in the ſouthern parts of Italy with fewer efforts of induſtry than in almoſt any other country in Europe. Hence ariſes a general propenſity to idleneſs, which is increaſed by the numerous charitable inſtitutions to which the Roman Catholic religion gives riſe. In the city of Naples there had long exiſted a body of perſons under the denomination of *Lazzaroni* or Beggars, amounting to the incredible number of from thirty to forty thouſand men, who did nothing, and ſubſiſted merely by charity, or by ſuch ſhifts as occaſionally occurred to them. One of theſe frequently was the menacing the ſtate with an inſurrection, in caſe their wants were not inſtantly ſupplied; which uſually drew from a feeble adminiſtration very liberal diſtributions of money and proviſions. On the preſent occaſion they demonſtrated abundance of loyalty; but the king had thought fit to avoid entruſting his ſafety to ſuch defenders. During the confuſion which followed the flight of the court and the approach of the French army, the Lazzaroni became mutinous.

French Revolution, 1799.

348 The Lazzaroni riſe againſt the French.

They heard that the French aboliſhed, wherever they came, all thoſe monaſteries and other religious eſtabliſhments which are the great ſources of public charity. The Lazzaroni, therefore, conceived the moſt violent hatred againſt them, and againſt all who were ſuſpected of favouring opinions hoſtile to royal government. In the beginning of January they began to ſhew ſymptoms of diſcontent, and in a few days broke out into open inſurrection. The members of the government left by the king, overcome by habitual terror of the Lazzaroni, conſulted merely their own perſonal ſafety, and made no effort to preſerve the public tranquillity. Prince Militorni had gained [illegible] plauſe on account of his vigorous def[illegible] gainſt the French. The Lazzar[illegible] him their commander in chief; [illegible] to reſtrain their violence and love of plunder. They declared hoſtility againſt the French, and all the adviſers of the armiſtice. They broke open the priſons, and put to death all thoſe who were confined on account of political offences againſt the royal government. They next ſpread t[illegible] in ſearch of thoſe perſons [illegible] they conſidered as favourable to the invaders, and committed murder and robbery in all quarters, concluding by burning the houſes of thoſe accounted diſaffected. An attempt was made by a conſiderable body of the inhabitants, who thought themſelves in the greateſt danger, to reſiſt their fury, by fortifying the convent of the Celeſtine, and retiring thither; but the Lazzaroni, after encountering the fire of cannon and of muſketry, ſucceeded in ſtorming the place, and deſtroyed all who had taken refuge there. Their power and their fury were now equally boundleſs, and the city became in many quarters a ſcene of maſſacre and pillage. Prince Militorni, therefore, went to Capua, and requeſted Championnet to reſcue Naples from utter ruin by occupying it with his army. For this purpoſe it was arranged, that a column of French troops ſhould ſecretly advance by a circuitous march, and ſuddenly enter the city from the oppoſite quarter. Before this plan could be fully executed, the Lazzaroni had adopted the daring reſolution of attacking the French within the fortifications of Capua. Accordingly two-thirds of them marched out upon this enterpriſe, and ſpent the 19th and 20th of January in attempting to take Capua by aſſault. Multitudes of theſe men here periſhed by the artillery of the place; for the

349 Their own [illegible]

French.

French Revolution, 1799.

French, to favour the capture of Naples by the party that had been sent eastward for that purpose, avoided making any sally, and remained upon the defensive. The Lazzaroni at Capua, however, having learned on the 21st that a French column had marched to Naples, and approached the gates, suddenly returned to the assistance of their brethren in the capital. They were closely pursued by the French; but they had leisure, nevertheless, to barricade the streets, and to form themselves into parties for the defence of different quarters. A dreadful and sanguinary contest now ensued, which lasted from the morning of the 22d to the evening of the 23d of January. The Lazzaroni, with some peasants who had joined them, disputed obstinately every spot of ground; and by the energy which they displayed, cast a severe reproach upon the feeble and unskilful government, which had not been able to direct in a better manner the courage of such men. At length, after having been gradually driven from street to street, the Lazzaroni rallied for the last time at one of the
350 gates of the city, where they were nearly exterminated.

350 They are nearly exterminated.

The inhabitants rejoiced on account of their own escape from immediate ruin; and while the French armies found themselves become odious in all the other countries which they had entered, they here found themselves, from the peculiar circumstances of the case, received with unfeigned welcome, in a city which holds the third place in population and splendour among the capitals of Europe.

This may be regarded as the last triumph enjoyed by the Directory. The consequences of their conduct [illegible] gathering fast around them. They were de[illegible] home; not only from the violations [illegible] to the constitution of their country, but also from the manner in which they conducted public affairs in detail. They set no bounds to their [illegible], or to the exactions with which their agents [illegible] the conquered countries. Championnet, ashamed [illegible] which the commissaries of the Directory [illegible], attempted in Italy to restrain [illegible] consequence was, that, upon the complaint of the commissary [illegible]poult, he was deprived of his command, and thrown into prison. Scherer, the minister of war, was appointed his successor. Under him the rapacity of the agents of government, and the embezzlement of the public stores, was carried to its
351 height. The numbers of the armies were suffered to decline, that the Directory, the commissaries, and the generals, might become rich. Thus the state was left totally unprepared against the storm which was now rapidly gathering from abroad. Still, however, France was feared by the neighbouring nations, to whom the present state of her internal affairs was obscurely known. Though an army of 45,000 Russians had advanced to the aid of Austria, yet that Cabinet hesitated to declare war. Prussia was eagerly solicited by Britain to take up arms against France, and large pecuniary aid was offered; but Sieyes, the Directory's ambassador at Berlin, artfully contrived to defeat this negociation, and to counteract the unpopularity of his country in Germany, by publishing the secret convention at Campo Formio, which we have already mentioned. This treaty demonstrated so clearly to the German princes the utter unconcern with which their independence and their interests were regarded by the head of the empire, that no steady co-operation with Austria could henceforth be expected from them. The greater number of them, therefore, resolved to maintain their neutrality under the protection of Prussia.

351 Rapacity of the Directory.

On the 2d of January, the French ministers at Rastadt presented a note to the congress, in which they intimated, that the entrance of Russian troops into Germany, if not resisted, would be regarded by them as a declaration of war. Some negociation took place in consequence of this note, but no satisfactory answer was returned. On the 26th of that month, the strong fortress of Ehrenbreitstein surrendered, after having remained under blockade since the conclusion of the treaty of Campo Formio. By the possession of this place, and of Mentz and Dusseldorf, France was now rendered very formidable on the Rhine. As she possessed also the strong country of Switzerland, and all the fortified places of Italy, she was well prepared, not only for defence, but for active operation; for it is now known, that the conferences of Rastadt were purposely protracted, by orders from the Directory, till the French armies should be ready to take the field with advantage against an enemy whose conduct betrayed the most culpable tardiness. At this time Jourdan commanded 352 on the Upper Rhine from Mentz to Huningen; Massena occupied with an army the eastern frontier of Switzerland towards the Grison country; Scherer was commander in chief in Italy; Moreau acted as general of a division under him; and Macdonald commanded the troops that occupied the territory of Rome and Naples. But these armies that kept in subjection, and were now to defend so many countries, scarcely amounted to 170,000 men in all, and were far outnumbered by the armies which Austria alone, without the aid of Russia, could bring into the field. The Directory, however, confiding in the unity of its own plans, in the undecided politics of the court of Vienna, and in the consequent slow movements of the Imperial armies, was eager to renew the war; and the two Councils, on the 13th of March, declared France to be at war with the Emperor of Germany and the Grand Duke of Tuscany. The war, however, had already been begun. On the 1st of March Jourdan crossed the Rhine at Strasburg, and occupied several strong positions in Swabia. Manheim was taken, and Philipsburg summoned to surrender by Bernadotte (G), while St Cyr entered Stutgard. On the 4th of March the Austrians crossed the Lech, under the command of the Archduke Charles, to oppose this army. Massena advanced into the territory of

French Revolution, 1799.

352 War renewed on the Rhine.

(G) This summons was conceived in very extraordinary terms, and cannot be accounted for but upon the supposition that Bernadotte believed the Austrian officers infected with French principles. He calls upon the commander of the fortress to surrender without resistance, and thus violate the trust reposed in him by his sovereign. He tells him, that a discharge of his duty would produce the *defection of his officers and men*. He warns him of the folly and danger of leading troops to action *against their will*; and, lastly, he threatens him with *vengeance* if he should *dare to resist!*

French Revolution, 1799.

of the Grifons; and furprifing a ftrong body of Auftrians, took them all prifoners, together with their General Auffenburgh, and the whole of his ftaff, after a defperate refiftance under the walls of *Coire*. The reduction of the Grifons was the confequence of this victory.

353 And in Switzerland.

But in order to complete the plan of the French, which was to effect a junction with their two armies, that of Maffena in Switzerland with that of Jourdan in Germany, it was neceffary to carry the important poft of Feldkirch, which was occupied by the Auftrian General Hotze, whofe line extended from the frontiers of the Grifons, to the north-eaft by the Vorelberg, to the eaftern extremity of the Lake Conftance. Vigoroufly repulfed in his firft attack, Maffena renewed it, five different times, with frefh forces, and increafed impetuofity. But all could not avail againft the fteady bravery of the Auftrians, who drove back the affailants with immenfe flaughter. The French, however, being in poffeffion of the Grifons, the invafion of the Engadine, and the county of Bormio, by a divifion of the army of Italy cantoned in the Valteline, under the orders of General Cafabianca, was facilitated. The Auftrians, too weak in that quarter to refift them, retreated into the Tyrol, whither they were purfued by the French, who forced fome of the defiles by which the entrance of that country was defended, and extended their deftructive incurfions as far as Glurenz and Nauders.

Meanwhile the van-guard of the main army of the Imperialifts pufhed forward to meet the enemy. On the 20th of March it was attacked by Jourdan, who drove in the outpofts; but on the following day that general was himfelf attacked in the centre of his army, driven from his pofition, and compelled to retire during the night to Stockach. Both parties now prepared for a decifive engagement. On the 24th, the Archduke encamped before Stockach, with his right wing towards Nellenburg, and his left near Wallenweis. On the 25th, at day-break, the French army began the attack. They directed their chief efforts againft the right wing of the Auftrians commanded by General Meerfeldt. The battle was long and obftinate. From five o'clock in the morning till paft one of the afternoon, its termination remained extremely doubtful. The French fucceeded in their attempt againft General Meerfeldt. His pofition was forced, and he retreated into a wood between Liptingen and Stockach. Here he renewed the combat without fuccefs. He was gradually driven to the extremity of the wood, though it is a German mile in breadth. The left wing of the Auftrians, however, had in the mean time maintained its ground, and reinforcements were fent from it to General Meerfeldt. With the affiftance of thefe he at laft fucceeded in making a ftand, and even obliged the French to retire in their turn. At length, about two o'clock, the French found it neceffary to withdraw from this quarter. The battle, however, was continued in different points till night came on. The French remained upon the ground where they had begun the attack, and they even retained 4000 prifoners whom they had taken during the various movements of the day. The refult of the battle, upon the whole, however, was fatal to their affairs. Their lofs was fo great, and the fuperiority of the Auftrians fo manifeft, that Jourdan dared not to hazard another engagement. On the following day he retired to Weiller near Dutlingen; and finding his army altogether unequal to offenfive operations, he fent back one part of it to cover Kehl and Strafburg, while he withdrew with the other towards Switzerland. This event compelled Maffena, who was preffing upon Tyrol and the Engadine, to return to the defence of Switzerland. He was immediately intrufted with the chief command of the troops in this quarter, in the room of Jourdan, who was removed. The Auftrians continued to advance in every direction, and immediately occupied the whole of the right, or German fide, of the Rhine, from the lake of Conftance to Mentz.

354 The French are defeated in Swabia.

355 And in Italy.

In Italy the fuccefs of the Auftrians was equally confpicuous, notwithftanding the treachery of the French in attacking them before the expiration of the truce. The attempt of the latter to force the advanced pofts of the former, on the 26th of March, at Santa Lucia and Buffelango, was rendered abortive; and at Legnago, the Auftrian general, Kray, obtained a complete victory, and compelled them to feek protection under the walls of Mantua. On the 5th of April, the Auftrians again attacked them in their pofition at Memiruolo, which lies on the road from Mantua to Pefchiera, and compelled them, after an obftinate conflict, once more to retreat. The lofs of the French in thefe different actions was undoubtedly great; but it is probably overrated at 30,000 men killed, wounded, and taken.

The fuccefs of the Auftrians, however, was not cheaply purchafed. Scherer, who commanded the French army, gained over them, at firft, fome advantages, which, had he known how to [illegible] might have given a different turn [illegible] One divifion of his army had [illegible] ftrian pofts on the 26th of [illegible] prifoners; but the other divifion [illegible] withdrew his troops from their advanced pofition, [illegible] thus relinquifhed the advantage which he had [illegible] Even on the 5th of April, Moreau's divifion [illegible] ed prodigies of valour, and took [illegible] prifoners; but from the [illegible] had been made by Scherer, [illegible] ported, and the victory of the Auftrians [illegible] Kray now quickly drove the French from [illegible] and compelled them, after having fuftained [illegible] to relinquifh their ftrong holds on the [illegible] and the Adige, and to retreat to the Adda.

356 Moreau fortifies his camp.

On the banks of this river, rendered remarkable for the dear-bought victories which Bonaparte had obtained at the bridge of Lodi, the French general Moreau, to whom the Directory had given the chief command of their army, prepared to make a vigorous defence. The military talents of this man had been rendered unqueftionable by his celebrated retreat through a hoftile country, and before a victorious army ably commanded. On the prefent occafion he did not belie his former character. Nothing that could give courage or confidence to his troops was neglected. Entrenchments were thrown up wherever the river was confidered as paffable; and a fituation, remarkably ftrong by Nature, was ftrengthened by every means which art could fupply.

Before this period, a confiderable body of Ruffians had joined the Imperialifts; and the chief command of the allied army was now affumed by Field Marfhal Suwarrow Rimnifki. This celebrated leader, whofe character

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357 Marshal Suwarrow

racter every democrate labours to misrepresent, had entered into the army at the age of twelve, and risen from the ranks to the station which he now holds, of Generalissimo of the Russian armies. Possessed of strong natural talents, he had likewise the benefit of an excellent education, and is said, by those who are personally known to him, as well as acquainted with the state of literature in Russia, to be one of the best classical scholars of all the natives of that great empire. He had studied, in early life, mathematics and natural philosophy, as branches of science absolutely necessary to the man whose highest ambition is to become a great commander; and his knowledge of the learned, as well as of the fashionable languages, has enabled him to avail himself of all that has been written either by the ancients or the moderns on the art of war. This art has indeed been his chief study from his youth; it has been at once his business and his amusement.

Possessed with his countrymen, in general, of the most undaunted courage, and formed by Nature to endure the greatest fatigue, it is not surprising, that with all these advantages Suwarrow should have long ago acquired the character of one of the ablest generals of his time. It is indeed true, that, till the opening of the campaign of 1799, he had distinguished himself only against the Turks, whom we are too apt to despise, and against the Poles when divided among themselves; but let it be remembered, that the enthusiastic courage of those same Turks had found employment for the talents of some of the ablest generals in Europe, a Laudohn and a Cobourg; and that the Polish armies which Su[illegible] were united by the strongest of all [illegible] that they must conquer or perish. [illegible] known to Frederic the Great, that [illegible] talents of the Russian hero in the [illegible] and the attention of all Europe was [illegible] towards the quarter where those talents were [illegible] in the support of social order, and [illegible] man. His operations in [illegible] the highest expectations which [illegible]. At an age considerably [illegible] he began a campaign not less remarkable [illegible] than any which had gone before it since the commencement of the French revolution. We are by no means prepared, however, to do justice to the various military efforts which were now made, or to explain clearly the means employed to insure success. If the work entitled the *History of Suwarrow's Campaigns* be deserving of credit, the superiority of that commander over his rivals and opponents seems to have at all times consisted principally in the promptitude with which he formed his plans, and the rapidity with which he carried them into execution. It is likewise said to be a maxim of his, always to *commence* the attack when he sees a battle inevitable, from the persuasion that the ardour of the attacking army more than counterbalances the advantage of ground, if that advantage be not very great. Such was certainly the principle upon which he acted at present.

358 Attacks him in his intrenchments,

On the 24th of April the combined army advanced to the Adda; and having driven in Moreau's outposts, Suwarrow resolved, on the 26th, to attack him in his entrenchments. For this purpose, while the shew of an attack was maintained along the whole line, a bridge was secretly thrown over among the rocks at the upper part of the river, where the French had thought such an enterprise unlikely or impossible. A party of the combined army was thus enabled, on the following morning, after crossing the river, to turn the French fortifications, and to attack their flank and rear, while the rest of the army forced the passage of the river at different points. The French fought obstinately, but were speedily driven from all their positions, and compelled to retire to Pavia, leaving 6000 men on the field; while upwards of 5000 prisoners, including 4 generals, fell into the hands of the allies, together with 80 pieces of cannon.

359 And defeats him with great slaughter.

The advantage thus obtained over the French, in consequence of the address with which the Adda was crossed, is said to have gained for Suwarrow more estimation from his antagonists than they had originally been disposed to grant to any military officer coming from Russia, and who had never before had personal experience of the mode in which war is conducted in the south of Europe. But this is probably affectation. The French had surely no cause to despise Russian generals, since they could not but know that Laudohn was born in Russia, that he had his military education there, and that he had risen to a high rank in the army before he entered into the service of the Empress Queen Maria Theresa. Indeed it is evident, that while their orators were declaiming against Suwarrow and his Russians as merciless barbarians, they were secretly trembling at his prowess and resources, which they could not but remember had more than once saved the armies of the Prince of Cobourg in the Turkish war.

Moreau now established the wreck of the French army, amounting to about 12,000 men, upon the Po, between Alessandria and Valentia. On the 11th of May he compelled a body of Austrians to retire, though they had already passed the river, and took a great number of them prisoners. On the following day, 7000 Russians crossed the Po at Basignano, and advanced on Pecetto. Moreau immediately fell upon them with his army. They maintained a long and desperate conflict; but being at last thrown into confusion, and refusing to lay down their arms, about 2000 of them were drowned in recrossing the river, and the French, with difficulty, took a small number of them prisoners. But Suwarrow soon advanced, and terminated this active, but petty warfare, which was all that the French could now maintain. Moreau was under the necessity of retiring with his troops to occupy the Bochetta, and other passes which lead to the Genoese territory; and the combined army commenced vigorously, and at once, the siege of all the fortresses in the part of Italy which it now occupied. Peschiera, Mantua, Ferrara, Tortona, Alessandria, and the citadels of Turin and Milan, were all attacked. The French were driven from the Engadine by Bellegarde; Massena, closely pressed in Switzerland by the Archduke Charles, was compelled to retreat to the neighbourhood of Zurich, and almost all Piedmont had risen in insurrection against the French; so that in every quarter their affairs seemed desperate. Few or no reinforcements arrived from the interior, and their generals were left to act upon the defensive, and to detain the enemy at a distance from the frontiers of France as long as possible. One effort of offensive war only remained, and, after some delay, it was made with much vigour.

Macdonald

360 Macdonald and Moreau concert measures for attacking the allies.

Macdonald was still with a considerable French army in the southern parts of Italy, and occupied the territories of Rome and Naples. No attempt was made on the part of the combined powers to cut off his retreat; probably from the conviction that such an enterprise could not be accomplished with success in the mountainous countries of Tuscany and Genoa, through which it would be in his power to pass. Aware of this circumstance, he was in no haste to remove, though the combined army now occupied almost the whole territory between him and France. He gradually concentrated his forces, however, and drew near to the scene of action. His army amounted to 30,000 men; and he was ordered by the Directory to evacuate the new-born republics of Rome and Naples, and to form a junction, if possible, with the army of Moreau. The present situation of the allies, however, tempted Macdonald to hazard an action by himself. Marshal Suwarrow had extended his forces over Lombardy and part of Piedmont, in order to afford protection to the well disposed inhabitants of these countries; and Macdonald and Moreau had concerted between them a plan for dividing their antagonists, and vanquishing them, as the French generals had often vanquished their enemies in detail. It was only by Macdonald, however, that any important blow could be struck; but it was necessary that Moreau should draw upon himself a great part of the Austro-Russian forces, that the remainder might be more completely exposed to his colleague's attack. For this purpose he had recourse to a stratagem.

361 Junction of the French and Spanish fleets.

Towards the end of April, the French fleet, amounting to 16 ships of the line, had ventured out of Brest harbour. Ireland was supposed to be the place of its destination; and the British fleet was stationed in the situations most likely to prevent its arrival there. The French, however, intending to form a junction with the Spanish fleet, which was still blockaded in the port of Cadiz, sailed southward. When they approached Cadiz, a storm arose, which prevented any attempt on their part to enter the harbour, and any effort on the part of the British admiral, Lord Keith, to bring them to an engagement. On the 4th and 5th of May, therefore, they passed the Strait of Gibraltar, and steered for Toulon Lord Keith kept his station near Cadiz till the 9th of May, and then entered the Mediterranean in quest of the French fleet. The Spaniards immediately put to sea, and went into the Mediterranean also. The French fleet entered Toulon, and afterwards went out in quest of the Spanish fleet. They sailed towards Genoa, and afterwards to Carthagena, where they met their allies. The two fleets being now united once more, passed Gibraltar, and sailed round to Brest, where they arrived in safety, without being overtaken by the British.

Moreau, in the mean time, took advantage of the arrival of the French and Spanish squadrons in the vicinity of Genoa, to spread a report that they had brought him a powerful reinforcement of troops, in the hope of withdrawing from Macdonald the attention of Suwarrow. This last officer was himself at Turin His advanced troops possessed the passes of Susa, Pignerol, and the Col d'Assiette; while, at the lower extremity 362 of the vast track of country over which his army was scattered, General Hohenzollern was posted at Modena with a considerable force, and General Ott was at Reggio with 10 000 men. On the 12th of June, Macdonald began his operations. His advanced divisions attacked Hohenzollern at Modena on that day, defeated him, and took 2000 of his men prisoners. The French, at the same time, attacked General Ott; and, after obliging him to retreat, they entered Parma on the 14th of June. On the 17th, General Ott was again attacked, and compelled to retire upon Castel St Giovanni. But here the progress of Macdonald was arrested.

362 Partial successes of Macdonald.

Suwarrow had been informed of his approach and alarming successes; and with that presence of mind, and that promptitude of energy, which so strongly mark the whole of his conduct, he suddenly left Turin on the 15th of June, at the head of 20,000 men; and having marched seventeen leagues in eight-and-forty hours, came up with Macdonald's army on the banks of the Tidone. The Russian Generals Rosenberg and Foerster commanded the right and the centre; the left wing was commanded by the Austrian General Melas; the Russian General Prince Procration commanded the advanced guard, [illegible] the reserve. A desperate action [illegible] with equal obstinacy on both [illegible] three successive days. At len[illegible] to the standard of Suwarrow, [illegible] The French, driven on the 1st day [illegible] the Trebbia, were there ultimately defeated on the [illegible] after a carnage on both sides, such as some of the [illegible] officers in the army declared that they had never before seen. The Russians and [illegible] each others line, and were mutually [illegible] appeared in person wherever [illegible] troops most closely pressed [illegible] killed under him, and to have [illegible] on the 19th, running on foot from rank to rank, to urge the troops forward by his presence and example (H). With all these exertions of heroism, however, and greater have seldom been made, the issue of the contest continued doubtful, till the gallant Kray, in direct disobedience to the pernicious orders of the Aulic Council at Vienna, arrived at the head of a large detachment from the army besieging Mantua, and, on the 19th, decided the fate of the day.

The French fled during the night; and, on the morning of the 20th, Suwarrow pursued them with his army in two columns. It seldom happens that German troops can overtake the French in a march. The Russians now did so, however; and at Zena the rear guard of the French, being surrounded, laid down their arms. The

(H) We had this information from an officer of high rank, now residing in Weimar, who was present in the action; and who added, that the Cossacs, as soon as they saw their old commander in his *shirt*, rushed upon the enemy with an impetuosity which nothing could withstand. The story is by no means incredible; for Suwarrow, who despises costume, is known to have fought repeatedly in his shirt against the Turks; and he would be as hot on the Trebbia as ever he was on the Danube.

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The rest of the French army found safety in the passes of the Appennines and the Genoese territory, after having lost on this occasion, in killed, wounded, and prisoners, not less than 17,000 men.

Moreau, in the mean time, had attacked the Austrians under General Bellegarde in the vicinity of Alexandria. Though superior to him in numbers, they were completely beaten; but Suwarrow having returned with infinite rapidity after his victory over Macdonald, the temporary advantage gained by Moreau became of no importance. Suwarrow complained loudly of the conduct of the Aulic Council on this occasion; while they, in return, imputed their disaster under Bellegarde to his unskilful distribution of the whole troops, which had exposed an immense army to great danger from the enterprises of an handful of men. It is not our business to decide between them. The instructions of the Council to Kray not to co operate with the commander in chief of the combined army, seem to us in the highest degree absurd, if not treacherous; and we have heard a general officer, whose name, were we at liberty to give it, would do honour to these pages, say, that the distribution of the troops, of which that council complained, was the most masterly thing that has been done during the war. Be this as it may, a distrust and mutual misunderstanding thus commenced, or, at least, made its first open appearance, which gave good reason to suspect that little cordiality of co-operation would long exist between these allies. They continued, however, for some time to enjoy uninterrupted prosperity under the command of Suwarrow. The sieges of the [illegible] fortresses were very closely pressed. They [illegible] in succession; and the period appeared [illegible] when it would be in the power of the [illegible] enter the ancient territory of France.

364 Mutual complaints of Suwarrow and the Aulic Council.

If we turn our eyes to a different quarter, we shall find the French as much humbled at this time in Palestine by British valour, as they were in Italy by the united armies of Russia and Austria. The hero of [illegible] the conqueror of Italy, the boasted legislator of [illegible], who having defeated the Mamalukes, taken possession of Alexandria and Cairo, and professed himself a Mahometan in Egypt, led an army into Palestine with the avowed purpose, it has been said, to take possession of Jerusalem, and by rebuilding the temple, and restoring the Jews, to give the lie to the prophecies of the Divine founder of the Christian religion. At the head of a chosen band, exceeding 12,000 in number, and possessed of a staff eminent for military skill and experience, he arrived at the small town of Acre, situated on the sea-coast, 28 miles south of Tyre, and 37 north of Jerusalem. To this town, which was wretchedly fortified, and defended only by a small garrison of Musselmans, he laid siege in form; and the governor would have surrendered unconditionally, had he not been, we say not *persuaded*, but *decoyed*, by an English *naval* officer, to make a vigorous resistance. We need not add, that the naval officer was Sir Sidney Smith, or that the besieging general was Bonaparte.

365 Bonaparte's unsuccessful attack of Acre.

The command of the garrison being entrusted to Sir Sidney Smith, who was not to be bribed by French gold, or corrupted by French philosophy, the hero who, by the aid of these allies, had so quickly routed armies, and conquered states in Italy, was detained before the town of Acre *fixty-nine* days; though the number of the allies who defended that town exceeded not 2000 men! Foiled in *eleven* different attempts to carry it by assault, one of which was made during the truce which he himself had solicited to bury the dead, he was ultimately obliged to retreat, leaving eight of his generals, eighty-five of his officers, and *one half* of his army behind him. The superiority of the British over the Corsican hero was, during this siege, more fully displayed in conduct than even in courage. The true magnanimity evinced by the former; his temperate replies to the audacious calumnies and atrocious falsehoods of his adversary; and the moderation and humanity which characterised his dispatches, and invariably marked his behaviour to those whom the fortune of war subjected to his power—give additional lustre to the brilliant victory which his valour, his energy, and his perseverance, so essentially contributed to secure.

But while we pay a tribute of justice to the merits of our gallant countryman, we must not omit to notice the high deserts of the brave, the loyal, the virtuous Philipeaux, his gallant comrade, the partner of his toils, and the partaker of his glory. The skill of this French officer as an engineer was most successfully displayed in the defence of Acre; and, indeed, his exertions on that memorable occasion so far surpassed his strength, that he actually perished through fatigue.

The defeat of Bonaparte at Acre, which effectually stopped his destructive career, will be considered as important indeed, when it is known that his arts of intrigue had so far succeeded as to prevail on the numerous tribe of the Druses to join his standard with *fixty thousand* men immediately after the reduction of that town. Had this junction been effected, it was intended to proceed to Constantinople, and, after plundering the city, to lay it in ashes! It is scarcely possible to calculate the dreadful consequences of such an event on the political state of Europe. If services are to be estimated in proportion to their effects, we know of none, during the present war, fertile as it has been in brilliant atchievements, that deserves a higher reward than the defeat of Bonaparte at Acre.

His vast projects, had he succeeded.

During these reverses abroad, France had begun to suffer much internal agitation, and the Directory found itself in a very difficult situation. The elections, as usual, were unfavourable to them; and amidst the contempt with which they now began to be regarded, it was no longer possible to secure a majority in the Councils, by unconstitutionally annulling the elections of their political opponents. They demanded money, and were answered by reproaches, on account of their profusion, and the rapacity of their agents. The royalists in the south and the west began to form insurrections. They were subdued with much difficulty, on account of the absence of the troops. The people had totally lost that enthusiasm which, in the earlier periods of the revolution, induced them to submit to so many evils, and to make the most violent efforts without murmuring. They beheld the renewal of the war with regret, and were unwilling to assist by their exertions to restore power and splendour to the faction which had trampled upon their freedom.

Amidst all these difficulties, an event occurred which, for a time, gave the Directory the hope of being once more able to rouse the dormant energies of their countrymen. After the defeat of Jourdan, a detachment from

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from the army of the Archduke Charles had occupied Rastadt, where the Congress still sat. On the 28th of April an order was sent by an Imperial officer to the French ministers, requiring them to quit Rastadt in 24 hours. They demanded a passport from Colonel Barbascy, who had sent the order; but this he could not grant, none having that power but the commander in chief.

367 Assassination of the French envoy

They declared themselves determined to depart without delay, although the evening approached. They were detained about an hour at the gate of the town, in consequence of general orders which had been received by the military to suffer none to pass. In consequence of an explanation, however, and of the interposition of superior officers, they were allowed to depart. The three ministers, Bonnier, Roberjot, and Jean Debry, were in carriages. The wife of Roberjot, and the wife and daughters of Jean Debry, were along with them; and they were attended by the ministers of the Cisalpine republic. When they had advanced to a very short distance from Rastadt, they were met by about 50 hussars of the regiment of Szeckler, who made the carriages to halt, and advancing to the first of them, containing Jean Debry, demanded his name. He told them his name, and added that he was a French minister returning to France On receiving this answer, they immediately tore him from his carriage, wounded him in several places with their sabres, and cast him into a ditch, on the supposition that he was killed. They treated in the same manner the two other ambassadors, Bonnier and Roberjot, whom they murdered upon the spot. They offered no personal violence, however, to the rest of the company, who were allowed to return to Rastadt; but they robbed the carriages of whatever effects they contained; and the papers of the ambassadors were conveyed to the Austrian commander. After the departure of the soldiers, and the return of the carriages to Rastadt, Jean Debry wandered about the woods all night, and returned also to Rastadt on the following day. He claimed the papers belonging to the legation from the Austrian commander, but they were refused to be restored.

During the whole of the long period that the Congress had sat, Rastadt and its vicinity had been occupied by French troops, and it was only a few days since the Austrians had obtained possession of it. This event therefore cast, at least, a severe reproach upon the discipline of the Austrian army. It did more; it made every honest man regret, that troops, engaged in the support of a good cause, should think to promote that cause by the murder even of the greatest villains. The Archduke Charles made haste to disclaim all knowledge of it in a letter to Massena; but the French Directory, regarding it as a fortunate occurrence, from its tendency to rouse the resentment of the nation, addressed to the two Councils, on the 5th of May, a message, in which they ascribed it to a deliberate purpose on the part of the Austrian government to insult France by the assassination of her ambassadors. They thus converted the private act of a few desperate individuals into a measure of public policy; as if the death of those wretched miscreants could have been of consequence to the enemies of the *great* nation. The unpopularity of the Directory, however, and the obvious inutility of so gross a crime, prevented this accusation from obtaining much credit, or producing great effects upon the people. In

368 Turned by the Directory to its own advantage.

a private letter which a friend of our's received at that period from the Continent, he was assured that the murder of the envoys "*fait plus de bruit que de sensation;*" and that the general opinion was, that the Directory itself knew more of the authors of that crime than the Archduke or the Austrian government.

369 Dissensions in France.

Upon the introduction of the new third of this year into the Councils, a violent opposition to the Directory commenced. Sieyes, who was ambassador at Berlin, and who had enjoyed, during the whole progress of the revolution, a very considerable influence over all the parties that had successively enjoyed the supreme authority, was elected into the Directory. At the first establishment of the constitution he had refused to occupy this station, and it excited much surprise when he readily accepted the office in the present calamitous state of the Republic. His admission into the Directory, however, did not reconcile the public or the two Councils to that body. A violent contest for power betwixt the Moderate and the Jacobin parties seemed to approach; but they soon came to a compromise. Treilhard was removed from the Directory, under the pretence that he had held an office in the state within less than a year previous to his nomination. Merlin and Reveillere were compelled to resign, to avoid an impeachment with which they were threatened; but Barras still contrived to retain his station. Moulins, Gohier, and Ducos, men little known, and by no means leaders of the contending parties, were appointed Directors. The power was understood to be divided, and that neither party greatly [illegible]. An attempt was made to revive public spirit, by [illegible] the institution of clubs, which [illegible] the Directory. The violent Jacobins [illegible] take advantage of this licence. The[illegible] ancient style, their proposals for violent measures, and their practice of denouncing the members and the measures of government. But the Directory becoming alarmed by their intemperance, obtained leave from the Councils to suppress their meetings, before they were able to interest the public in their [illegible].

Considerable efforts were now made by the French government to recruit their armies; but the deranged state of the finances, which the votes of the Councils could not immediately remedy, prevented the possibility of their gaining a superiority during the present campaign. The difficulty was also increased by the necessity of resisting immense armies in different quarters at the same time, France being assailed at once on the side of Holland, Switzerland, and Italy. Such, however, were the exertions of the Directory, that they seemed not destitute of the hope of being able speedily to assume, on the frontier, a formidable, and even menacing posture. In the beginning of August, their Italian army amounted to 45,000 men. The different bodies of troops of which it consisted had been drawn together, and concentrated nearly in the same positions which Bonaparte had occupied before his battles of Montenotte and Millesimo. The command of the whole was given to Joubert, a young man, who had been much distinguished under Bonaparte; and who, in the style of gasconade employed by that general, assured his government of victory, declaring, that he and Suwarrow should not both survive the first battle. In this boasting declaration he seems to have been in earnest;

371 Joubert assumes the command in Italy.

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earneft; for, on taking the command, he prevailed with Moreau to remain in the army as a volunteer till the firft battle fhould be fought. The allies had now taken Turin, Aleffandria, Milan, Pefchiera, and Ferrara, with a rapidity which would lead one to fuppofe that fome new mode had been invented of materially abrid-

372 Succeffes of the allies.

ging the duration of fieges. The ftrong citadel of Turin opened its gates, to the aftonifhment of Europe, after a bombardment of only *three days;* the citadel of Aleffandria furrendered to the Auftrian General Bellegarde, on the 22d of July, after a fiege of *feven days;* and the ftill more important fortrefs of Mantua furrendered to the brave General Kray, on the 29th of the fame month, after a fiege of only *fourteen days.* The garrifon of Aleffandria amounted to 2400 men; that of Mantua to 13,000. The former were detained prifoners of war, and the latter were allowed to return to France on their *parole;* a parole which the commanders of the allied armies could not reafonably expect to be kept. This has given rife to a fufpicion, that the fortrefs was voluntarily furrendered to the Auftrians, in order that the Directory might recruit its armies with the garrifon.

The allies next began to befiege Tortona, and Joubert refolved to attempt its relief. He hoped to accomplifh this object, and to gain fome advantage over their army, before General Kray could arrive to the affiftance of Suwarrow with the troops that had been occupied in the fiege of Mantua. On the 13th of Auguft, the French drove in the whole of the Auftrian [illegible] poffeffion of Novi. Here they encam[illegible] fteep, but not high, ridge of hills, [illegible] Novi, their right towards Sera[illegible] towards Bafaluzzo. On the 14th [illegible] quiet; and on the 15th they were at[illegible] by Suwarrow, whofe army was now reinforced by the arrival of General Kray from Mantua. The [illegible] army was commanded by Kray, [illegible] centre was occupied by the [illegible] (Procration) and [illegible] The attack began at 5 o'clock in the morning, and was continued during many hours. Soon after the commencement of the battle, while the French commander in chief, Joubert, was urging his troops forward to a charge with the bayonet, he received a mufquet fhot in his body, and, falling from his horfe, immediately expired. Moreau inftantly refumed the command. After an obftinate conteft, the allied army gave way, and was compelled to fall back in all quarters. The attack, however, was repeatedly renewed, and much blood was fhed. From the obftinate manner in which they fought, the Ruffians, in particular, fuffered very feverely. They made three unfuccefsful efforts againft the centre of the French army, and on each occafion thofe immediately engaged were rather deftroyed than repulfed. The laft attack along the whole line was made at three in the afternoon. The French remained unbroken; and the day muft have terminated in the defeat of the allies, had not General Melas fucceeded in turning the right flank of the French line. Their right wing was thus thrown into confufion. Melas purfued his advantage till he obtained poffeffion of Novi, and the whole French army made a rapid retreat under the direction of Moreau.

According to the accounts given by the Auftrians, the French loft in this battle 4000 killed and an equal number taken prifoners. They acknowledged their own lofs in killed to be equal to that of the French, but the lofs fuftained by the Ruffians was never publifhed. The general refult of the battle was the total ruin of the French affairs in this quarter. The allies retained their decided fuperiority; and there was no enterprife which, on the prefent theatre of the war, they might not have ventured to undertake. The French renounced all hope of defending Genoa, and prepared to evacuate that city and its territory. The Directory expected an immediate invafion of the fouth of France, and addreffed a proclamation to the people, urging them to act with firmnefs and energy amidft the calamities with which the country was now menaced. 374

Unaccountable conduct of the allies.

But thefe apprehenfions were unneceffary. The court of Vienna had other objects in view that were lefs dangerous to their enemy. They neither invaded Genoa nor France, but quietly proceeded in the fiege of Tortona. The vanquifhed army was furprifed to find itfelf unmolefted after fuch a defeat; and in a few days ventured to fend back parties to inveftigate the movements of the allies. The new commander Championnet, who had fucceeded Joubert, found to his no fmall aftonifhment that they had rather retreated than advanced; and he immediately occupied the fame pofitions which his army had held before the battle of Novi.

Inftead of purfuing the advantages they had gained in Italy, the Aulic council, or council of war at Vienna, now perfuaded Suwarrow to leave that country with his Ruffians, and to fet out for Switzerland to drive the French from thence. In the early part of the campaign, the Archduke Charles had fucceeded, after various attacks, in driving the French from the eaftern part of Switzerland beyond Zurich, of which laft city he retained poffeffion. The Directory, however, had fent their new levies chiefly towards this quarter; fo that in the middle of the month of Auguft Maffena's army amounted to 70,000 men. The Archduke was now fo far from being able to purfue the advantages he had gained, that of late the French had returned the offenfive, and threatened to endanger his pofition. Their right wing under Lecourbe had even fucceeded in taking poffeffion of Mount St Gothard, which is the great pafs that leads from the centre and eaftern part of Switzerland into Italy. The cabinet of Vienna probably wifhed to throw the fevereft duties of the war 375

Suwarrow leaves Italy, and marches to Switzerland.

upon their northern affociates. The veteran Suwarrow had never, during his long military career, fuffered a fingle defeat. His prefumption of fuccefs was therefore high; and he perhaps felt himfelf not a little flattered by the requeft to undertake an enterprife in which the Auftrians had failed, though led by their moft fortunate commander. It is indeed certain that he confidered himfelf as called out of Italy too foon. Though confident of being properly fupported, he agreed to proceed with his troops from Piedmont to Switzerland, where another Ruffian army had lately arrived. Delays, however, were thrown in his way. Tortona did not fall quite fo foon as was expected; and when he was ready to march, the Auftrian commander in Italy refufed to fupply him with mules for the tranfport of his baggage. Unable to reply to the indignant expoftulations of the Ruffian hero, this man defcended to a pitiful falfehood, by affuring him that he would find a

 fufficient

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sufficient number of mules at Bellinzone, where, when he arrived, not one was to be had. He had now no other resource but to dismount the cavalry, and employ their horses to drag along the baggage. Under all these difficulties, he arrived, by forced marches, on the confines of Switzerland, on the day appointed by him and the Archduke; but the Austrian cabinet had, in the mean time, taken a step which made all his exertions useless.

376 Is deserted if not betrayed, by the Austrians.

Thinking it degrading to a Prince of the Imperial house, who had so long held the highest military rank, to serve under the Russian General, and not having the confidence to require the most experienced leader in Europe to receive the orders of a man so young as the Archduke, they sent that prince with his army to attack the French, who, in a small body, had entered into Swabia. He began accordingly to draw off his troops in the beginning of September, before Suwarrow was in readiness to leave Italy. The number which he took with him has been differently estimated, the lowest computation stating it at 48,000, and the highest at 60,000. The former is the most probable; since it is well known that 20,000 would have been fully adequate to the purpose for which he marched. The army which he left behind him is more perfectly ascertained: it consisted of 21,000 Russians, 18,900 Austrians, Bavarians, and other auxiliaries, forming a total of 39,900 men.

Upon what principle of military tactics the Aulic council could suppose that a skilful and intrepid commander like Massena, with a force nearly double that of the allies, would remain in a state of inactivity, it is not easy to conceive. He perceived at once the advantage which might be derived from this unaccountable movement of the Archduke. The French troops in Swabia were therefore ordered to advance rapidly, and to threaten the rear of the Archduke's army. As the repulse of these troops, and the invasion of France towards Alsace, formed a part of the Austrian commander's plan of operations, he marched against them with his army. The French made as much resistance as the smallness of their force would permit. The Archduke, however, gradually drove them towards the Rhine. The better to carry on their plan of deception, they made a serious stand in the neighbourhood of Manheim, and were defeated with the loss of 1800 men. The Austrians entered Manheim, and seemed ready to cross the Rhine in this quarter.

All this while Switzerland was left completely exposed to the enterprises of Massena. General Hotze, with the Austrians, occupied the right wing of the allied army there. The newly arrived Russian army was stationed in the centre at Zurich, under the command of General Korsakof; and the left, consisting chiefly of Bavarians and other troops of the empire, was commanded by Nauendorf. Massena remained quiet till he learned that the Archduke had entered Manheim, and that Suwarrow, having taken Tortona, was on his march towards Switzerland by Mount St Gothard.

377 The allies defeated in Switzerland.

This last position was defended by Lecourbe; and Massena resolved, in the mean time, to anticipate the arrival of Suwarrow. On the 24th of September, having drawn the attention of the Russians to another quarter by a false attack, he suddenly crossed the Limmat, a river which divided the two armies near the convent of Farr, which is three leagues distant from Zurich. A part of the French troops engaged the Austrians, while the greater part of the army marched against the Russians at Zurich. The Austrian General Hotze was killed in the commencement of the action: General Petrarch, who succeeded him in the command, contrived to avoid a total rout, and retired during the night with the loss of about 4000 men. The contest with the Russians was singularly obstinate. In a mountainous country, to which they were strangers, and contending against the most skilful military leaders that the south of Europe had been able to produce, they laboured under every disadvantage. They could not be put to flight, however; and even when different divisions of them were surrounded, they refused to lay down their arms, and were slaughtered upon the spot. By the retreat of the Austrians on the evening of the 25th, they found themselves on the 26th nearly surrounded in Zurich. They now began to retreat also; and we are only surprised at the ability of the Russian General in effecting his retreat in such good order, and with such little loss; for if the official accounts deserve credit, his loss in killed, wounded, and taken, did not exceed 3000 men. He was obliged, however, to abandon his baggage and cannon to the enemy.

378 Suwarrow's march.

During these operations, Suwarrow was advancing on the side of Italy with an army rated, in some accounts, at 18,000, in others at only 15,000; and forcing the French from [illegible] ng positions on Mount St Gothard, [illegible] very day on which Massena made his general attack, into the valley of Urseren; and driving Lecourbe before him, with considerable slaughter, advanced as far as [illegible] penetrated on the next day into the [illegible] and took 1000 of the French prisoners; while the Russian General Rosemberg was equally successful in the canton of Schwitz, where General Auffenberg had effected a junction with him; and General Linken defeated and took another corps of French, consisting of 1300 men.

379 His admirable conduct.

Massena, however, now turned upon the Field-marshal with the greater part of his army; and, by hemming him in on all sides, expected to have made him, and the Grand Duke Constantine, prisoners. Suwarrow, however, defended himself against every attack with unexampled vigour and address. A single pass among the mountains was all that remained unoccupied by the French. He discovered this circumstance, and escaped, though closely pursued. He lost his cannon, baggage, and provisions, among the dreadful mountains and precipices with which that country abounds. He made his way, however, eastward through the Grison country, and at length arrived at Coire with about 6000 men in great distress.

Nothing could exceed the indignation of this old warrior when he discovered the manner in which affairs had been conducted, the hazardous state in which the Russians had been abandoned by the Archduke, and the consequent ruin which they had encountered. He considered himself and his countrymen as treacherously exposed to destruction; he loudly complained of the Commander of the allied forces in Switzerland; publicly taxed the council of Vienna with selfishness and injustice; and refused all farther co-operation with the Austrian army. He sent an account of the whole trans-

380 His indignation at the court of Vienna.

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action to St Petersburgh in a letter, of which the composition would do honour to the finest writer of the age, and withdrew with his troops to the neighbourhood of Augsburg to wait for farther orders.

380 Invasion of Holland.

In the mean time, Great Britain prepared to invade Holland with an army of 40,000 men, consisting of British troops and Russian auxiliaries. The first division, under General Sir Ralph Abercromby, sailed in the month of August, under the protection of a fleet commanded by Admiral Lord Duncan. Bad weather prevented a landing from being attempted till the 27th. On the morning of that day the troops landed without opposition upon the shore of Helder Point in north Holland, at the entrance to the Zuyder Sea. They had not been expected in this quarter, and the troops in the neighbourhood were consequently few. The British, however, had no sooner begun to move forward, than they were attacked by a considerable body of infantry, cavalry, and artillery, who had been hastily assembled from the nearest towns. The Dutch troops maintained the contest with much obstinacy; but they were gradually fatigued by the steady opposition they encountered, and retired to the distance of two leagues. In the night they evacuated the fort of Helder, of which the British took possession on the morning of the 28th. A detachment from the British fleet, commanded by Vice Admiral Mitchell, now entered the Zuyder Sea by the strait of the Texel, to attack the Dutch fleet

381 Capture of the Dutch fleet.

under Admiral Story. This last officer, instead of retiring for safety to any of the ports, or to the shallow water with which that sea abounds, surrendered the [illegible] 30th of August without firing a [illegible] that his seamen were mutinous, [illegible]

Had the expedition terminated here, it might have [illegible] regarded as extremely fortunate, and as establishing the power of the [illegible] navy without a rival. But it was [illegible] his first success by an effort on land to restore the [illegible] of the Stadtholder, and the ancient government of the United Provinces. Many circumstances were hostile to this enterprise. The whole army had not been sent at once from Britain. As no more than the first division had arrived, the troops could only rest upon the ground they had gained till reinforcements should be sent. The terror arising from the first appearance of an invading army was thus allowed to pass away, the enemies of the present Dutch government were discouraged, and leisure was afforded to adopt effectual measures of defence. The place where the landing was effected was well chosen for an attack upon the Dutch fleet; but for an invasion, with a view to the restoration of the Stadtholder, it was the worst that could have been selected. North Holland, at the extremity of which it was made, is a narrow peninsula, everywhere intersected by canals and ditches, of about 40 miles in length. Here the invaders might be detained, and even successfully resisted, by a force greatly inferior to their own. This also is the quarter of the country the most unfavourable to the cause of the Stadtholder. In Zealand, where his estates are situated, and in Rotterdam, which is full of Scotchmen and of families of Scottish extraction, his friends are numerous and powerful; but in Amsterdam, and in North Holland, which is under its influence, his enemies abound, and the resistance to his power has been very great during every period of the Dutch history. When to all this it is added, that the rainy season was approaching, and that a winter campaign in Holland is almost impossible, it will not appear surprising that this expedition was attended with little ultimate success. It is said that, amidst the pressure of the many difficulties which surrounded them, the French Directory hesitated much about undertaking the defence of Holland; but the place, and the time of landing the invading army, at once brought them to a determination. General Brune was sent thither, with whatever troops could be hastily collected, to support the Dutch General Daendels.

382 Progress of the invaders.

General Abercromby, in the mean time, remained upon the defensive at Schager Brug, waiting for reinforcements. His inactivity encouraged the enemy on the 10th of September to venture an attack upon his position. They advanced in three columns, two of which consisted of Dutch and one of French troops. They were repulsed, however, in all quarters, and retired to Alkmaer. On the 13th the Duke of York arrived with additional troops, and assumed the chief command. The Russian auxiliaries having also arrived, offensive operations were immediately resolved upon. On the 19th the army advanced. General Abercromby commanded the left, which proceeded along the shore of the Zuyder Sea against Hoorne. The centre columns were commanded by Generals Dundas and Pultney; and the right wing, consisting of Russians, was commanded by their own General D'Herman. In consequence of some strange misunderstanding, the Russians advanced to the attack soon after three o'clock in the morning, which was some hours previous to the movement of the rest of the army. They were successful in their first efforts, and obtained possession of the village of Bergen; but pressing eagerly forward, and being unsupported by the other columns, they were nearly surrounded. Their commander was taken prisoner; and though the British came in time to protect their retreat, they lost at least 3000 men. This failure on the right obliged the British Commander in Chief to recal his troops from the whole advanced positions they had gained, though General Abercromby had actually taken Hoorne with its garrison, and although General Pultney's column had carried by assault the principal position of the Dutch army called *Greb Copp l.*

The severity of the weather prevented another attack till the 2d of October, when, after an engagement that lasted from six in the morning till the same hour in the evening, the British army succeeded in driving the united Dutch and French troops from Alkmaer and the villages in its neighbourhood. The contest was chiefly conducted among the sand hills in the vicinity of the ocean; and the battle was maintained with such obstinacy, that the fatigue of the troops, together with the difficult nature of the country, prevented the British from gaining any great advantage in the pursuit. The retreating army immediately occupied a new position between Baverwyck and Wyck op zee. The Duke of York once more attacked them on the 6th; and after an obstinate and bloody engagement, which was maintained till night, he remained in possession of the field

383 Stopped by the enemy and the inclemency of the weather.

of battle. But this was the last success of the invaders. Finding himself unable to make farther progress, in consequence of the increasing numbers of the enemy, the impracticable nature of the country, and the badness

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of the weather, which, during the whole of this year, was unusually severe, the Duke of York retired to Schager Brug, and there waited for orders from England to return home. He was, in the mean time, closely pressed by the United Dutch and French forces, so that his embarkation must have been attended with much hazard. He therefore entered into a convention with the French and Dutch generals; by which it was agreed, that they should no farther molest him in his retreat, and that, in return, he should not injure the country by breaking down any of the dykes which protect it against the sea, and that Great Britain should restore to France and Holland 8000 prisoners of war, taken previous to the present campaign.

In consequence of these events, the affairs of France now began to assume a less unfavourable aspect. They were indeed driven to the extremities of Italy, Championet was defeated in every effort which he there made against the Austrians during the rest of the year, and Ancona, which was the last place of any strength possessed by the French, also surrendered on the 13th of November to General Frolich; but they retained the Genoese territory, and Switzerland and Holland continued under their power. The new coalition against them seemed once more ready to dissolve. From the commencement of the French Revolution, a spirit of selfishness had mingled with all the efforts made by the continental powers of Europe against it, and had rendered them fruitless. To prevent the aggrandisement of Austria, Prussia had early withdrawn, and still stood aloof. Spain and Holland were retained under the influence of France by the efforts of her arms, and by the universal diffusion of her wild principles among the people. Even the British cabinet, which of all the European powers has remained most true to the original purpose of the war, sometimes forgot that object. Thus, when invading Holland, the Dutch were informed, by a proclamation, that their ancient government was to be restored; but no offer was made to restore their distant possessions. Of all the coalesced powers, however, Austria pursued her separate interests with the least disguise. With much facility she relinquished the Netherlands, and suffered the principal bulwarks of Germany, Mentz, and Ehrenbreitstein, to fall into the hands of the French, upon obtaining in exchange the Venetian territories, which Bonaparte had conquered, and thought himself authorised to sell. During the present campaign, the whole conquests made by the united efforts of the Austrian and Russian forces were seized by Austria in her own name, and none of the Princes of Italy obtained leave to resume the government of their own territories. This conduct on the part of the allies gave every advantage to the French. They broke off the negociations at Lisle, under the pretence of defending the Dutch and Spanish settlements which the British government refused to relinquish. They found it easy to alarm the King of Prussia, by displaying the unbounded ambition of the house of Austria; and the Emperor of Russia, having publicly declared to the members of the German empire, that the purpose for which he had taken up arms was not to dismember France, but to restore peace to Europe, became jealous of the Court of Vienna, when he saw it pursue a conduct so very different. This jealousy was encreased by the misfortunes of the Russian troops; and all circumstances seemed now to promise that the new coalition would speedily be deserted by its northern auxiliary.

254 Coalition against France ready to be dissolved.

While affairs were in this state, an event occurred which exhibited the French Revolution under a new aspect. When Bonaparte found himself compelled to retreat, baffled and disgraced, from the ruins of Acre, he learned that a Turkish army was ready to invade Egypt by sea. He returned, therefore, with his usual celerity, by way of Suez, across the desart of Arabia Petrea, which divides Syria from that country, and was in the neighbourhood of the Pyramids on the 11th of July, when an army of 18,000 Turks landed from 100 ships at Aboukir. They took this fort by assault, and gave no quarter to the French garrison of 500 men that it contained. On the 15th, Bonaparte began to march down the country against them. On the 25th he came in sight of them, at six o'clock in the morning.

255 Bonaparte vanquishes the Turks in Egypt

It is not wonderful that those barbarians afforded him an advantage which had so often been presented by the armies of Austria. They had divided their force into two parts, which were encamped on the opposite sides of a beautiful plain. He had now formed a considerable body of cavalry, by obtaining for his men fleet horses from Arabia. These advanced rapidly into the centre of the Turkish army, and cut off the communication between [illegible] parts. His infantry then attacked the [illegible] the Turks. [illegible] ed to fly to [illegible] the sea. [illegible] tacked. It [illegible] soon also put to flight. Some [illegible] sea, and perished in attempting to [illegible] their fleet; the rest took [illegible] ge in [illegible] kir. The [illegible] reached France towards the end of September, and revived [illegible] naparte's [illegible] ictories, contrasted with [illegible] the Republican armies [illegible] 10th of October [illegible] the Directory, [illegible] count of the cap[illegible] whole remains of [illegible] army. On the 14th of the same month a message from the [illegible] announced, to the astonishment of all men, that [illegible] aparte, along with his principal officers, had just arrived in France, and that they left the army in Egypt in a prosperous state. This last part of the message was soon afterwards proved, by the intercepted letters of Kleber, and the other generals left behind, to be a scandalous falsehood. In one of these letters, Poussielgue says, "Every victory carries off some of our best troops, and their loss cannot be repaired. A defeat would annihilate us all; and however brave the army may be, it cannot long avert that fatal event."

[illegible] Arrives with his principal officers in France,

Bonaparte, however, was received at Paris with distinction, though nobody could tell why he had deserted his army and come thither. The parties in the government were equally balanced; and both the Jacobins, and what were called the *Moderates*, solicited his assistance. The Jacobins still possessed a majority in the Council of Five Hundred; but in the other Council their antagonists were superior. The Director Sieyes was understood to be of the party of the Moderates; and the Jacobins had of late unsuccessfully attempted

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to remove him from his office, under the pretence that the interval appointed by the constitution had not elapsed between his going out of the Council of Five Hundred and his election to the office of director. Neither party was satisfied with the existing authorities; but none of the usual indications of approaching hostilities appeared. The Jacobins were far from suspecting that Sieyes had a plot ripe for execution, which was to overwhelm them in an instant. They were even in some measure laid asleep by an artful scene of festivity, in which the whole members of the Councils were induced to engage, on the 6th of November, under pretence of doing honour to the arrival of Bonaparte. On the morning of the 9th, one of the committees of the Council of Ancients, called the committee of Inspectors of the Hall, presented a report; in which they asserted, that the country was in danger, and proposed to adjourn the sitting of the legislature to St Cloud, a village about six miles from Paris. We have already mentioned, that the constitution entrusted to the Council of Ancients the power of fixing the residence of the legislative bodies, and that this Council could in no other case assume the initiative, or propose any law; their powers of legislation being otherwise limited to the unconditional approbation or disapprobation of the decrees passed by the Council of Five Hundred. The Council of Ancients now suddenly decreed, that both Councils should meet next day at St Cloud. As the Council of Five Hundred had no constitutional right to dispute the [illegible] party in [illegible] silently [illegible] the 10th of [illegible] Hundred exhibited a scene of [illegible] received a letter from Legarde, [illegible] Directory, stating, that four of its [illegible] resignation of their offices, and that [illegible] in custody by order of General [illegible] of their [illegible] the Coun[illegible], attended [illegible]. He [illegible] brother Lucien Bonaparte [illegible] president. Great confusion ensued; he was called a Cromwell, a Cæsar, an usurper. The members began to press upon him, and his countryman Arena attempted to stab him with a dagger. He was rescued by his military escort. Lucien Bonaparte then left the chair, and cast aside the badge of office which he wore as a member of the Council. The confusion did not diminish; but in a short time a party of armed men rushed into the hall, and carried off Lucien Bonaparte. A tumultuous debate now began; in which it was proposed that Bonaparte should be declared an outlaw. The debate was soon terminated, however. The doors of the hall were once more burst open. Military music was heard; and a body of troops proceeding into the hall in full array, the members were compelled to disperse. The Council of Ancients, in the mean time, setting aside the constitution, passed a variety of decrees. They abolished the Directory, and appointed in its stead an Executive Commission; to consist of Bonaparte, Sieyes, and Roger Ducos, under the appellation of Consuls. They adjourned the sittings of the legislative bodies till the 20th of February, and appointed two committees, consisting of twenty-one members, selected from each of the two councils, to act as legislators in the mean time. They also expelled a great number of members from their seats in the councils.

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Most of the members of the Council of Five Hundred returned to Paris, after having been driven from their hall by the military; but a part of them remained at St Cloud, and, on the evening of the same day, confirmed all the decrees of the Council of Ancients. The new government entered upon its functions at Paris on the following day. That city remained tranquil, and the public funds even rose upon the occasion. On the 17th of November the consuls decreed the transportation of a great number of the leading Jacobins and zealous republicans to Guiana, and ordered many others to be imprisoned; but these decrees were speedily recalled, and affairs went on as quietly as if nothing unusual had occurred.

388 [illegible]tions of Tippoo Sultan in India.

While Bonaparte was thus obtaining boundless personal aggrandisement in Europe, the African expedition in which he had been engaged was utterly unsuccessful in all its objects. The circumstances which led to it, so far as concerned foreign nations, now came to light, and were shortly these: Tippoo Sultan, the son and successor of the celebrated Hyder Ally, and sovereign of the Mysore country, which forms a part of the peninsula of India, had been compelled to conclude a treaty of peace in the year 1792 with the British governor general, Lord Cornwallis, under the walls of Seringapatam his capital. By this treaty he resigned to the invaders a part of his territory, and agreed to pay a large sum of money. He was, moreover, under the humiliating necessity of consenting that two of his sons should be delivered as hostages, to remain with the British till the pecuniary payments could be completed.

A war thus concluded could not become the foundation of much cordial amity between the parties. Tippoo had inherited from his father a deep sentiment of hostility against the growing power of Britain in India. Though he submitted on the occasion now mentioned to the necessity of his circumstances, yet he only waited a more fortunate opportunity to endeavour to recover what he had lost; and even, if possible, to accomplish the favourite object of all his enterprises, the complete expulsion of the British from India. At a former period, almost the whole of the native princes of this vast continent had entered into a combination against the power of Britain; but their designs had been defeated by the talents and exertions of Warren Hastings, Esq; The ascendency of the British government in this quarter was now so great, that no such combination could again be formed, and Tippoo felt that its power could only be shaken by the aid of an European army. France was the only country from which he could hope to obtain an adequate force. By the events of the revolution, however, and by the pressure of the war at home, the rulers of France had been prevented from attending to distant views and interests. Their settlements in India had been seized by the British, and they had ceased to retain any possessions beyond the Cape of Good Hope, excepting the islands of Mauritius and Bourbon. In the year 1797, Tippoo resolved to endeavour to renew his intercourse with the French by means of these islands. One Repaud, who had once been a lieutenant in the French navy, and had resided for some time at Seringapatam,

389 He renews his intercourse with the French.

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gapatam, had misled Tippoo into a belief that the French had a great force at the Mauritius, which could immediately be sent to his aid in case of a war. He therefore fitted out a ship, of which he gave the command to Ripaud, and sent two persons in it as his ministers, with powers to negociate with the French leaders at the Mauritius. But, at the same time, to avoid exciting the suspicions of the British government in his neighbourhood, he directed his messengers to assume the character of merchants, to act in that capacity in public, and to conduct their political negociations with secrecy. They arrived at the Mauritius towards the close of the year 1797, and opened their proposals to Malartic the governor, for an alliance between Tippoo and the French nation, with the view of obtaining the aid of an European army. They were received with great joy, and vessels were instantly dispatched to France to communicate their proposals to the Directory.

In the mean time, Malartic the governor of the Mauritius, from folly, from treachery, or from a desire to involve Tippoo, at all hazards, in a quarrel with the British, took a step which ultimately was in a great measure the means of defeating the plans, and accomplishing the ruin of that prince. On the 30th of January 1798, he published and distributed a proclamation, in which he recited the whole private proposals of Tippoo, and invited all French citizens to enlist in his service. Copies of this proclamation were speedily conveyed by different vessels, touching at the Mauritius, to the continent of India, to Britain, and to all quarters of the world. Accordingly, as early as the 18th of June 1798, the secret committee of the Court of Directors of the East India Company in London wrote to their governor general in India, requiring him, in consequence of this proclamation, to watch the conduct of Tippoo, and even to engage in hostilities, if the measure should appear necessary. Before that period, however, the government in India had been alarmed, by the same means, and was making preparations for war. This, however, was no easy matter. It is the nature of European power, in these countries, gradually to decline. The nature of the climate, the view of returning home, and the distance from the seat of government, speedily introduce a relaxation of the efforts and the vigilance by which dominion was originally acquired. The troops require to be continually renewed by levies from the parent country; and if this precaution is neglected for a very short time, or negligently attended to, they become unable to protect the extensive territories such as Britain now possessed in India. When Lord Mornington, the governor-general, enquired into the state of the British army at Madras, and whether he might hazard an offensive war against Tippoo; he was informed, that three, if not six months would be necessary to assemble the scattered divisions of the army, and to prepare them to defend their own territory. It was added, that such was the feeble state of the British forces in that quarter, that it might even be unsafe to excite suspicion in Tippoo by military preparations, as he might, in that case, ruin them by a sudden attack Lord Mornington, however, resolved to encounter every hazard, and ordered immediate and active preparations in every quarter.

390
His
[illegible] detected by the British.

In the meanwhile, Tippoo did not trust for success to the aid of France alone. He endeavoured to bring an attack upon the British and their allies, or subjects, in India, from the north-west, by inviting Zemaun Shah to invade the country. This prince is at the head of a formidable kingdom, made up of provinces torn from both Persia and India. It was founded about sixty years ago by Ahmed Khaun Abdalla, an Affghan chief, who followed Nadir Shah on his invasion of India in 1739. He himself afterwards invaded India no less than seven times; and, in particular, he overthrew, with dreadful slaughter, the united forces of the Mahratta empire, in the year 1761, on the plains of Paniput. He was succeeded, in 1773 by his son Timmur Shah, who died, and was succeeded by his own son, the present prince. The dominions of Zemaun Shah extend from the left bank of the river Indus, on the seacoast, as far northward as the latitude of Cashmeer; and from east to west they are 650 English miles in length, comprehending the provinces of Cabal, Candahar, Peishere, Ghizni, Gaur, Sigistan, and Korasun. He usually keeps in pay an army of 150,000 horse, besides infantry to garrison his fortresses. In expectation of direct aid from France, by Bonaparte's expedition to Egypt, and of an important diversion to be made by Zemaun Shah, Tippoo endeavoured to remain quiet, and to temporise with the British.

Since the [illegible] of Lawrence and of Clive, the native princes of India have been eager to introduce the European [illegible] their [illegible] For this purpose [illegible] to command and [illegible] endeavour to [illegible] of European soldiers. [illegible] British, [illegible] fluence, [illegible] able body [illegible] and of [illegible] ment. These under the command [illegible] possessed great influence at Hyd[illegible] the Nizam. It was of much [illegible] should be [illegible] to obtain [illegible] proaching [illegible] procured [illegible] success, that, on [illegible] French corps under Perou [illegible] without bloodshed, and a British force was [illegible] as a guard to the Nizam [illegible] The military preparations being in a considerable state of forwardness, Lord Mornington next warned Tippoo Sultan, in a letter dated the 8th of November 1798, of his having a knowledge of his hostile designs and connection with the French. He also proposed to send an ambassador to treat about the means of restoring a good understanding between the states. Tippoo avoided returning an answer till the 18th of December, and then merely denied the accusation, and refused to receive the ambassador. On the 9th of January 1799, the British governor again urged in writing that the ambassador should be received. No answer was returned for a month; and, in the mean time, an army of 5000 men having arrived from England, orders were issued to General Harris to advance at the head of the Madras army against the kingdom of Mysore. Tippoo now offered to receive the ambassador, providing he came without an attendance; but this concession was not accounted sufficient, and the army advanced. An army from

French Revolution 1799.

from Bombay was, at the same instant, advancing on the opposite side of his dominions. A part of Tippoo's forces encountered this army and were defeated; and within a few days thereafter, on the 27th of March, the rest of his army was defeated by General Harris. When an European army in India is tolerably numerous, the detail of its military operations against the natives is by no means interesting; for the inhabitants of these enfeebling and fertile regions can never be made, by any kind or degree of discipline, to possess that moral energy which enables men to encounter danger with coolness and self-command. They can rush on death under the influence of rage or despair, but they cannot meet the hazard of it with calmness and recollection. It is sufficient to remark that, on the 7th of April, General Harris sat down before Seringapatam. On the 9th, Tippoo sent a letter to this officer, alleging his own adherence to treaties, and enquiring into the cause of the war. He was answered by a reference to Lord Mornington's letters. On the 20th he made another attempt to negociate, by writing to General Harris, requesting him to nominate commissioners to treat of a peace. In answer to this [illegible], certain articles were sent to him as the only conditions that would be granted. By these he [illegible] required to surrender half his dominions, to pay a large sum of money, to admit resident ambassadors from the British and their allies, to renounce all [illegible] with the French, and to [illegible] stipulations. On the [illegible] to General [illegible] ambassadors; [illegible] that he [illegible] of peace [illegible] have [illegible] the in[illegible] was [illegible] effect of [illegible] in [illegible] troops to [illegible] till the [illegible] besiegers [illegible] a breach [illegible] on the 4th of May. [illegible] had been chosen for this purpose, as the hottest hour of the day, and consequently the time when it would be least expected. Tippoo was in his palace; but on being informed of the attack, he hastened to the breach, and fell undistinguished [illegible] conflict. [illegible] treasures, and the plunder of the city, which was immense, went to enrich the conquering army, after deducting a share for the British government and East India Company. His kingdom immediately submitted. The part of it which formed the ancient kingdom of Mysore, was bestowed upon a descendant of the former race of its kings, whom Hyder Ally had deprived of the sovereignty; the additional territories that had been conquered by Hyder Ally were divided between the British and their allies, the Nizam and the Mahrattas. The family of Tippoo were either taken in the capital, or voluntarily surrendered themselves to the conquerors. They were removed from that part of the country, and allowed a considerable pension.

In the mean time, Zemaun Shah had actually invaded India from the north-west. He advanced to the vicinity of Delhi, spreading terror and desolation wherever he came. Had the French army in Egypt been able to detach a body of 15,000 men to the assistance of Tippoo, while all India was in the state of alarm naturally produced by the approach of this northern invasion, it is extremely probable that the British forces might speedily have found themselves deserted by every ally, and sunk under an unequal contest. But the actual result was very different. Satisfied with the plunder he had obtained, Zemaun Shah soon withdrew; and the French army being detained in Egypt by the war with the Turks, and by the want of vessels at Suez wherewith to reach India, Tippoo was left to contend, unassisted, against the whole power of Britain, and of its allies in the east. By the conquest and division of his territory, the British power was left without a rival in that quarter of the world, and raised to such a state of imposing superiority, that if affairs are only preserved in their present situation, by periodical supplies of European troops, no native prince, or even combination of princes, can henceforth bring it into danger. Thus, notwithstanding the vast military efforts made by the people of France during this revolutionary war, yet all foreigners who trusted to their aid were ruined by placing confidence in them. In Italy, Germany, Switzerland, and Holland, the rapacity of the commissaries of the French government, soon rendered odious and intolerable the presence of those armies whose arrival had been eagerly desired. In Ireland and in India, the promise and the hope of assistance which they were never able to bestow, only served to produce premature hostility, and to encrease and establish the power of the British government. 393 Immense power of Britain in India.

But to return to the domestic history of France, which has now become only an history of the usurpation of Bonaparte.

394 New constitution of France.

In the middle of the month of December, the Consuls, with their legislative committees, produced to the public their plan of a new constitution, which they presented to the primary assemblies, and which is said to have been accepted by them without opposition, like all the former constitutions. It is a very singular production, and neither admits of representative government, nor indeed of any other form of political freedom. Eighty men, who elect their own successors, possess, under the appellation of a *Conservative Senate*, the power of nominating the whole legislators and executive rulers of the state; but cannot themselves hold any office in either of these departments. The sovereignty is concentrated in one man, who, under the title of *Chief Consul*, holds his power for ten years, and may be re-elected. The whole executive authority is entrusted to him, and he enjoys the exclusive privilege of proposing new laws. He is assisted by two other consuls, who join at his deliberations, but cannot controul his will. The legislative power is entrusted to two assemblies: the one, consisting of 100 members, called a *Tribunate*; and the other, of a *Senate*, of 300 members. When a law is proposed by the Chief Consul, the Tribunate may debate about it, but have no vote in its enactment. The Senate votes for or against its enactment, but cannot debate about it. Neither the Consuls, nor the members of the legislative bodies, nor of the conservative senate, are responsible for their conduct. The ministers of state, however, who are appointed by the

French Revolution, 1799. the Chief Consul, are responsible for the measures they adopt.

The people in the primary assemblies elect one-tenth of their number as candidates for inferior offices; persons thus chosen, elect one-tenth of themselves as candidates for higher offices; and these again elect a tenth of themselves as candidates for all the highest offices of the state. Out of this last tenth the Conservative Senate must nominate the consuls, legislators, and members of their own body. But this last regulation is to have no effect till the ninth year of the republic. In the mean time, the same committees that framed the constitution, appointed also the whole persons who were to exercise the government. Bonaparte was appointed Chief Consul, and Cambaceres and Lebrun second and third Consuls. Sieyes, with his usual caution, avoided taking any active share in the management of public affairs, and was appointed, or appointed himself, a member of his own Conservative Senate; the whole being regarded as produced by him. As a gratuity for his services, the Chief Consul and his legislators presented to him an estate belonging to the nation, called *Crosne*, in the department of Seine and Oise.

395 Absolute power of Bonaparte. Thus, after all their sanguinary struggles for freedom, did the son of a Corsican drive from their stations the representatives of the French nation, and assume quiet possession of the government of that country, with a power more absolute than ever belonged to its ancient monarchs. The established privileges of the clergy, the nobles, and the parliaments, always restrained, in some degree, the despotism of the kings of France; these being now destroyed, the will of Bonaparte could meet with no controul. Though an usurper, however, he has not hitherto been a tyrant. He has rather attempted to induce the French nation to acquiesce in his authority, in consequence of the mildness with which it has been exercised, and of the ability and reputation of the men whom he has employed in the public service. He immediately sent proposals for negociating peace to the different powers at war with France. Great Britain refused to listen to him on account of the probable instability of his government, and Austria appears to have given a similar refusal. It is indeed difficult to believe that he wished his proposals to be accepted. They were not addressed to the belligerent powers in the aggregate, but to each individually, as if his object had been to sow dissention and mistrust between the allies. When he made these proposals, he did not even know whether the people of France would accept of the constitution which he had offered them; and he had taken no measures to procure a repeal of those revolutionizing decrees which were the immediate cause of the war with England.

396 Difficulty of his situation. His situation is, in the mean time, attended with great difficulties. The want both of an hereditary title, and of a national representation as the basis of his power, renders his character as an usurper so obvious, that it is only by very cautious measures that his elevation can be maintained. If he is either unsuccessful abroad, or compelled to press the people for money at home, there is little doubt that his fall must follow. Even independent of either of these events, it is a possible case that the violent Jacobins may recover their lost energy, and by force or fraud destroy the man who has baffled all their projects. From the royalists he has less to fear; for the men of ardent spirits and violent passions belonging to that party, from whom alone great efforts can ever be expected, were early tempted to leave the country by the hopes held out to them by the coalesced powers, which, by weakening, has hitherto prevented their party from becoming of much importance in the interior of France.

1800. In the mean time, Bonaparte has been successful in suppressing a new royalist revolt which had arisen in La Vendee, and has made great exertions to begin the campaign with vigour. The low state of the French finances, however, have much enfeebled all his efforts towards assembling very numerous armies. The army which he left in Egypt, after concluding a treaty with the Grand Vizier, by the terms of which they were to be landed safe in France, have seen reason to break the truce which had been agreed on. Kleber has attacked and completely defeated the main body of the Turkish army, while a detachment of that army has entered Cairo, and massacred, it is said, every Frenchman found in the city, not sparing the members of the National Institute. The probable consequence of this is, that no part of the army of Egypt will ever return to Europe. 397 Army of Egypt.

War has been recommenced between the Austrians and France, both in Switzerland and in Swabia, and carried on with great vigour. Massena, after giving complete proofs of consummate skill, and the most undaunted valour, has been for some time blocked up in Genoa; and unless he has been relieved by the vigorous exertions of the Chief Consul, he must before this period (June the 12th) have surrendered to the Austrian General Melas. The affairs of the French in that quarter seem indeed to be [illegible]; but in Germany they have hitherto been successful. [illegible] wonted abilities, and the gallant [illegible] before him, whether from necessity or to [illegible] inextricable difficulties, a very short time will evince. 398 Recommencement of war in Europe.

But here we shall interrupt this detail, without the faintest prospect of bringing it to [illegible] during the publication of the [illegible]. We cannot, however, dismiss the [illegible] without correcting some errors [illegible] which we fell in the account of the rise and progress of this revolution which was published in the *Encyclopædia*. We do not consider these errors as di[illegible] to ourselves; for in the midst of commotions which have convulsed all Europe, it is hardly possible to arrive at the truth. When time shall have cooled the passions of men, and annihilated the parties which now divide the nation, the calm voice of Truth may be everywhere heard; but when the article referred to was written, the ears of every man was stunned with the clamour of faction. 399 Abrupt conclusion of this narrative. 400 Errors in the former part of the article corrected.

So sensible of this are the editors of the only impartial periodical history* which we have, that they venture not to publish their volumes till several years have elapsed from the era of the transactions which these volumes record; whilst their rivals—the panders of faction—seize the earliest opportunities of obtruding their partial statements and false reasonings on the public mind.

* *Old Annual Register.*

It cannot be supposed that one or two men, superintending the publication of a work so extensive, and treating of subjects so various, as ours, have leisure or opportunity to examine with much attention the correspondence of ambassadors, or to expiscate truth from the contradictory publications of the day. We are

French Revolution. therefore obliged to draw our materials from such works as profess to give a summary, but impartial, detail of what is acting on the theatre of the world; and by these works we have often been misled. For the first error, however, which we shall notice in our former account of the rise of the revolution, we cannot plead even this excuse. We ought to have known, that the French clergy and French noblesse were not exempted from the payment of taxes; and, of course, we ought not to have assigned such exemption as one of the causes of the REVOLUTION. See that article, *Encycl.* n° 8. and 9.

401 First error. By a writer, to whose patriotic exertions this country is deeply indebted, it has been proved, with a force of argument which precludes all possibility of reply, that the exemption from taxes so loudly complained of was very trifling, that it was not confined to the nobility and clergy, and that it did not extend over the whole kingdom of France. "The *vingtiemes*, which may be considered as an impost merely territorial, was paid alike by the nobility and the *tiers-etat*. A great part of the clergy was indeed exempted; but their contributions, under a different form, constituted an ample equivalent. The duties upon the different articles of consumption were of course paid by all the consumers, except that in the *pays d'etat*, such as Artois and Brittany; the two first orders were exempted from paying the tax upon liquors. But these exemptions cannot be deemed very important, when it is known, that in the province of Artois they did not exceed 800 guineas annually [illegible] including the exemptions enjoyed by the privileged members of the *tiers-etat*." The British officers [illegible] of war are exempted from [illegible] of the state on [illegible] believe no good subject has ever murmured at that exemption. The French nobility were subject to the pole-tax.

"Of the *taille*, the impost from which it has been falsely asserted that the nobility and clergy enjoyed a total exemption, there were two species; the one *personal*, the other *real*. In one part of the kingdom, the right of exemption was [illegible] to the [illegible]ty; in the other, to the quality [illegible] In the first case, the privilege was enjoyed by every class of persons, by the tenants as well as the proprietor of a fief; whilst the gentleman, whose estate was holden by a different tenure, was obliged to pay the tax. In those provinces where the other custom obtained, the exemption was confined to a certain extent of property, and to *that* only while it continued in the actual occupation of the privileged person; but as it very seldom happened that the French nobility kept any land in their own hands, and as the tax payable by the farmers was of course deducted from the rent, the *teilles* was, in this case, ultimately paid by the landlord. The same observations apply, with still greater force, to the clergy, who always let their estates."

In a word, it appears from a formal declaration made by M. Necker to the Constituent Assembly, that all the pecuniary exemptions enjoyed by the privileged classes did not exceed L.292,000; that the exemptions appertaining to the privileged persons of the *tiers-etat* amounted to one half of that sum; and the *drôits de contrôle*, or duty imposed upon public deeds, and the high capitation tax (proportioned to their rank), paid by the nobility and clergy, made ample amends to the revenue for the partial exemptions which they enjoyed from other taxes. So far indeed were the *tiers-etat* from murmuring at the exemptions of the privileged orders, that, previous to the illuminism of the 18th century, they displayed, at every convention of the states-general, the greatest anxiety to maintain the rights of the nobility and clergy; and humbly supplicated their sovereign to suffer no invasion thereof, but to respect their franchises and immunities *.

* See Gifford's Letter to the Earl of Lauderdale, 2d ed.

We must likewise acknowledge, that in n° 11. of our article REVOLUTION, we have drawn a very overcharged picture of the miseries and oppression of the French peasants under the old government. It is indeed true, 402 Second error that they were obliged to serve in the militia, the establishment of which was conducted in France nearly on the same principles as it is in England. The men were called out by ballot only for a few days in the year during peace, when they received regular pay; but if a militia forms the best constitutional defence of a state, this surely ought not to have been considered as a grievance, especially since married men were exempted from the service. The nobility, too, were exempted from the risk of being drawn, for the best of all reasons—because most of them had commissions in the regulars, and because such as had not were engaged in professions, which rendered it impossible for them to serve in the militia. In France, as elsewhere, the peasants would no doubt be averse from this service, and might look perhaps with an anxious eye to the supposed immunities of their privileged superiors: but if mirth, good humour, and social ease, may be considered as symptoms of felicity and content, these men surely were not miserable; for these symptoms never appeared in any people so strong as among the French peasants. They were indeed liable to be called out by the intendants of the provinces to work a certain number of days every year on the public roads; but to this species of oppression, if such it must be called, the Scotch peasants are liable, and were still more so than at present, during that period when our parliamentary orators declare that the inhabitants of Britain enjoyed as much freedom as is consistent with the public tranquillity. It ought to be remembered, too, that Louis XVI. whose highest gratification seems to have consisted in contributing to the ease and welfare of his subjects, thought he saw the necessity of abolishing the custom of the *corvée*, and had made considerable advances towards the accomplishment of that object some years before the commencement of the revolution.

403 The French monarch not despotic. That the French monarch was despotic; that no man in the kingdom was safe; that nothing was unknown to the jealous inquisition of the police; and that every man was liable, when he least expected it, to be seized by *lettres de cachet*, and shut up in the gloomy chambers of the Bastile—has long been common language in England, and language which we must confess that we have adopted (REVOLUTION, n° 12.) without due limitations. The French government was certainly not so free as that of Britain; but he who understood it better than we do, and whose writings betray no attachment to arbitrary power, expressly distinguishes between it and *despotism*. "If (says Montesquieu) France has, for two or three centuries past, incessantly augmented her power, such augmentation must not be ascribed to fortune, *but to the excellence of her laws* †."

† De l'Esprit des Loix, liv.

This

French Revolution.

This, furely, is not the language of a man who thought himfelf governed by an arbitrary tyrant whofe *caprice* is the law; nor will it be faid to be the language of one who was either afraid to fpeak the truth or not mafter of his fubject.

404 No charge of the old conftitution wifhed by the people of France.

The inftructions of all the different orders to their reprefentatives, before the fatal meeting of the States General under the unfortunate Louis, are drawn up in language fimilar to that of this illuftrious magiftrate, and furnifh a complete proof that they knew themfelves to be fafe under the government of their monarchs. "The conftitution of the ftate (fay the clergy) refults from the *fundamental laws*, by which the refpective *rights* of the *king* and of the *nation are afcertained*, and from which not the fmalleft deviation can be made. The firft of thefe laws is, that the government of France is purely monarchical. The nation muft preferve inviolate the form of its government, which it acknowledges to be a *pure monarchy regulated by the laws*; and fuch it will have it to remain."

On the 28th of November 1788, in a general committee of the nobles affembled at Verfailles, the Prince of Conti delivered a note to the prefident, which was fanctioned by the concurrence of moft of the other princes of the blood, and was fuppofed to fpeak the general fenfe of the nobility; in which it was infifted, that the *profcription of all* NEW SYSTEMS *was neceffary* to infure the ftability of the throne, of *the laws*, and of *order*; and that the conftitution, *with the ancient forms*, fhould be preferved entire. In their inftructions to their reprefentatives, they infift that it fhall be exprefsly and folemnly proclaimed, that the conftitution of the French empire is fuch, that its government is, and muft remain, monarchical; that the king, as fupreme chief of the French, is only fubordinate to the fundamental law of the kingdom, according to which the conftitution muft be eftablifhed on the facred and immutable principles of monarchy, tempered by the laws; and this form of government cannot be replaced by any other conftitution.

"Let our deputies (fays the third eftate), before they attend to any other object, affift in giving to France a truly monarchical conftitution, which muft invariably fix the *rights* of the *king* and of the *nation*. Let it be declared, that the monarchical is the only form of government admiffible in France; and that in the *king alone*, as chief of the nation, is vefted the power of *governing according to the laws*." Is this the language of men groaning under the iron rod of defpotifm, or wifhing to reduce the power of the crown?

Even after the power of the crown was almoft annihilated and the order of nobility done away, fo far were thefe innovations from being acceptable to the enlightened part of the French nation, that in many departments of the kingdom they excited open infurrections, whilft the members of all the provincial parliaments oppofed them with unanfwerable arguments furnifhed by the law. The chamber of vacation of the parliament of Touloufe, in particular, protefted againft the proceedings of the States General, becaufe the deputies, who were empowered only to put an end to the ruinous ftate of the finances, could not change the conftitution of the ftate without violating their inftructions, and the faith fworn to their conftituents *.

* See the proteft at large in *Bertrand's Mem.* vol. i. c. 13.

That *lettres de cachet* were liable to abufe, and that occafionally they were grofsly abufed, is certain. The ufe of them ought therefore to have been either annulled, or, which would have been infinitely better, fubjected to fuch rules as fhould prevent all danger from them to the real liberties of the people; for the government would be of no ufe whatever which fhould poffefs no power capable of being abufed by defpotifm. Yet after all the noife that has been made about *lettres de cachet*, it is but juftice to obferve, that in the towers of the Baftile, when it was taken by the mob, were found no more than feven prifoners; of whom four were confined for forgery; one was confined at the requeft of his family on charges of the moft ferious nature; and two were fo deranged that they were fent next day, by thofe philanthropifts who had taken them out of comfortable chambers, to the mad houfe! That the chambers of the Baftile were as comfortable as the chambers of a prifon could be, we are affured by M. Bertrand de Moleville, who can be under no inducement to deceive the Britifh public, and whofe opportunities of difcovering the truth were fuch as no man will call in queftion.

405 Lettre de cachet.

406 Blunder of Necker.

In our account of the opening of the States General, we have expreffed too much deference to the character of M. Necker. To that man's irrefolute, if not treacherous, conduct, may, with truth, be attributed all the fubfequent miferies of France. It was about the mode of verifying their powers that the [illegible] ftate firft [illegible]; but this mode fhould have been defined by [illegible] different bailiwicks [illegible]. Even this omiffion [illegible] of the deputies at [illegible] been admitted into the hall of [illegible] the king have [illegible] fatisfied [illegible] thefe cau[illegible] have got the afcendant over the other [illegible] the bufinefs of the [illegible] as formerly [illegible] rejection [illegible] ill qualified [illegible] fis; and his abfenting [illegible] meafure which he [illegible] betrayed [illegible] ingratitude to his gracious [illegible].

In our account of the royal feffion, we were led into a miftake, which calls loudly for correction. The circumftances of that feffion were very different from what they appeared to us when we wrote n° 24. and 25. of the article REVOLUTION. The royal feffion was proclaimed in confequence of the violent ufurpations of the *tiers-etat*, and the irreconcileable differences which fubfifted between that body and the two higher orders; and fo far is it from being true that the prefident and members of the third eftate found their hall *unexpectedly* furrounded by a detachment of guards, that their fittings were only *fufpended*, for the beft of all reafons, with thofe of the other orders. To be convinced of this, we need but to attend to the following proclamation which was made by the heralds, on the 20th of June, between feven and eight o'clock in the morning, in the ftreets and crofs-ways of Verfailles:

407 Royal Seffion.

"June 20th. (By order of the King.) The King having refolved to hold a royal fitting in the States General, on Monday next the 22d of June, the preparations to be made in the three halls ufed by the affem-

French Revolution.

blies of the orders, make it neceſſary that thoſe aſſemblies ſhould be ſuſpended until after the ſaid ſitting. His Majeſty will give notice, by another proclamation, of the hour of his going to the Aſſembly of the States on Monday."

M. Bailly, the preſident of the *tiers-etat*, had been made acquainted with the object of this proclamation, by a private letter which was ſent to him by the Marquis de Brezé at ſeven o'clock in the morning; and to which he replied, "that having received no orders from the King, and the aſſembly having been announced for eight o'clock, he ſhould attend where his duty called him."

He repaired, accompanied by a great number of the members of the *tiers-etat*, to the door of the hall of the States, demanded admiſſion: and on being refuſed by the officer on guard, according to his orders, with which he acquainted him, he declared that he proteſted againſt ſuch orders, and that he ſhould give a report of them to the Aſſembly. To do this he had not far to go, as three-fourths of the deputies of the *tiers-etat*

408 Factious insolence of the aſſembly.

were already collected round him, or in the avenue leading to the palace. There it was that, ſurrounded by an immenſe crowd of people, they declaimed in the moſt violent manner againſt this pretended act of deſpotiſm. "The National Aſſembly is to be diſſolved (ſaid they), and the country to be plunged into the horrors of a civil war. *Want* rages every where; every where the people *ſee famine* ſtaring them in the face. This we were about to put an end to, by tearing the veil which [illegible] the mono[illegible]s, the [illegible] of miſcreants. The [illegible] the Richelieus, the Mazarins, [illegible] with their deſpotiſm only indi[illegible]; but here it is the whole nation [illegible] made the ſport of the whims of a deſpot miniſter. [illegible] upon the *Place d'Armes* (ſaid [illegible]); there we ſhall recal ſome [illegible] the [illegible] the *National Aſſemblies of* [illegible] in the gallery of the [illegible] new light, by [illegible] the language of liberty in this corrupt hall, where a little while ſince the head of him who ſhould have uttered that ſacred word would have been devoted to [illegible] executioner.—"No, no (ſaid a third), let us go to Marli, and hold our ſitting on the Terrace;—let the King hear us; he will come from his palace, and will have nothing more to do than to place himſelf in the midſt of his people to hold the royal ſitting."

At the concluſion of theſe declamations, the ſole object of which was to alarm and exaſperate the people, the Aſſembly decided upon transferring their ſitting to the Tennis-court, in the ſtreet called *Rue du Vieux Verſailles*. There M. Bailly read the letter which he had received from M. de Brezé, and his anſwer to it; which he had ſcarcely done, when a ſecond letter from M. de Brezé was put into his hands, the contents of which were as follows:

"It was by the King's poſitive order, Sir, that I did myſelf the honour of writing to you this morning, to acquaint you that, his Majeſty purpoſing to hold a royal ſitting on Monday, and ſome preparations being requiſite in the three halls of the Aſſemblies of the orders, it was his intention that no perſon ſhould be admitted into them, and that the ſittings ſhould be ſuſpended till after that to be held by his Majeſty."

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In this there was ſurely no marked diſreſpect to the repreſentatives of the people; but ſuch notions were countenanced by M. Necker, who appears indeed, on this occaſion, to have been in cloſe compact with the leaders of the mob. The popular violence that was employed to compel the majority of the clergy to join the *tiers-etat* is well known; and we have, in *Bertrand's Annals of the Revolution*, what amounts to dence almoſt *legal*, and quite ſufficient to enforce conviction, that Necker directed that violence.

In our account of the commotions which were excited in Paris on the firſt diſmiſſion of that miniſter and his baniſhment from the kingdom, we have been led by our democratic journaliſts to give circulation to a groſs calumny publiſhed by them againſt the Prince de Lambeſc. (See REVOLUTION, n° 36. and 37.) The truth, which is ſo much diſguiſed in theſe two numbers, is as follows:

"A detachment of the Royal Allemand, ſent to diſperſe the mob which was patroling the ſtreets in proceſſion with the buſts of Necker and the infamous Orleans, received a volley from the French guards as they were paſſing their quarters on the *Chauſſée d'Antin*, ſtopped to return it, and continued their march without quickening their pace. There were ſome ſoldiers killed and wounded on both ſides, but fewer of the regiment of Royal Allemand than on that of the French guards. 409 Conduct of the Prince de Lambeſc vindicated.

"The detachment marched to the Place Louis XV. and there found a body of dragoons who had been diſperſing the proceſſion. The two buſts were broken to pieces; and the populace in their fright taking refuge in the garden of the Thuilleries, the Prince de Lambeſc purſued them thither, at the head of the detachment of Royal Allemand, according to the orders which he received. This ſmall troop coming up to the head of the *Pont-tournant* (or turning bridge), at the extremity of the garden, found a kind of barricade, haſtily formed by chairs heaped upon one another: while they were removing this obſtacle, they received a ſhower of ſtones, broken chairs, and bottles, from the two terraces, between which the Prince de Lambeſc drew up his troop, keeping conſtantly at their head. Some guns and piſtols were diſcharged at them, which did no hurt; but ſeveral of the troopers were much bruiſed by the things that had been thrown at them, and an officer was ſeverely wounded by a ſtone.

"The Prince de Lambeſc, keeping at ſix paces from the bridge, oppoſed only a ſteady front to the aggreſſions of the populace. Seeing that this poſt became untenable, and that it was impoſſible for him any longer to reſtrain his troopers from repelling force by force, he gave the order for retreating out of the garden. At the ſame inſtant a cry was heard from all ſides of, *turn the bridge, turn the bridge*; and ſome perſons, in conſequence, ran and began to do it. The Prince de Lambeſc, juſtly fearing that a moſt bloody carnage would be the inevitable conſequence of it, ordered ſome piſtols to be fired in the air towards the bridge, to awe thoſe who were ſtriving to turn it. As the report of this volley did not deter them, he rode up himſelf, and with his ſabre ſtruck one of thoſe who were working hardeſt. The man ran off; and the Prince paſſing the bridge with

French Revolution. with his detachment into the Place Louis XV. drew up near the Statue, and being soon joined by the Swiss regiment of Chateauvieux, took his post with this force near the *Garde-meuble*, where he remained some time, having placed the infantry before him. At ten at night part of the troops were dismissed to their quarters, and the rest sent to Versailles." These facts being all judicially confirmed, prove how much the Prince de Lambesc's conduct was calumniated by those journalists whose detail we rashly adopted.

410 True account of the taking of the Bastile; In our account of the taking of the Bastile, misled by our treacherous guides, the journalists, we have greatly magnified the military skill and prowess of the assailants. That celebrated fortress was defended by a garrison consisting of no more than 114 men, of whom 82 were invalids. It was attacked by 30,000 men and women, armed with muskets and pikes, and furnished with a train of artillery which they had found at the *Hotel des Invalids*, given up to them by the timidity of the governor. Even this multitude would have been quickly repulsed from the Bastile, if the governor of that state-prison, who had received no orders from the court, had been less reluctant to shed the blood of his rebellious countrymen; for the Parisian mob had then displayed nothing of determined courage. A few discharges of musquetry, and one of canister-shot from a single cannon, had thrown them into confusion, and made them skulk behind the walls, when the ill-timed humanity of the governor made him enter into a treaty with the rebels, stipulating only that the garrison should not be massacred. How the stipulation was observed with respect to the governor himself, we have faithfully related; but we were mistaken when we said that the "French guards succeeded in procuring the safety of the garrison." The guards, with the utmost difficulty, saved indeed some of them, but most of the invalids remaining in the courts of the castle were put to death in the most merciless manner.

411 And of the murder of M. de Flesselles. Our account of the murder of M. de Flesselles (nº 40.) appears likewise to be very incorrect. This man was president of the Assembly of Electors at Paris (See REVOLUTION, nº 45.), and had not quitted the *Hotel de Ville*, where their rebellious meetings were held, during the whole time of these dreadful commotions. He had even signed all their atrocious resolutions, but became suddenly suspected from the consternation which he manifested at the sight of so many horrors, and especially at the cruel and treacherous murder of the governor of the Bastile. The consequence was, that he was treacherously murdered himself by one of the villains composing that assembly in which he presided. "The electors (says M. Bertrand de Molleville) hoped to extenuate the horror of this assassination, by causing it to be considered as a natural and almost lawful vengeance for a treachery, the proof of which they pretended to have. In fact, they declared, that when M. de Launay, the governor of the Bastile, was arrested, a letter had been found in his pocket from M. de Flesselles, containing this expression: 'I am amusing the Parisians with cockades and promises; hold out till night, and you will receive a reinforcement.' But this supposed letter, which, had it existed, they would not have failed to preserve very carefully, was never seen by any body; and I heard M. Bailly himself say, in a visit he paid me when he left the mayoralty, that he had no knowledge of it, and that it was not in his power to refer to any one who had told him that he had read it."

412 Ambition and cowardice of the Duke of Orleans. In our account of the earlier transactions of the Revolution, we omitted to mention a very extraordinary instance of ambition to which the Duke of Orleans was incited by Count Mirabeau, but which that unnatural monster wanted courage to carry into effect. During the commotions which prevailed in the capital on the dismissal of M. Necker from the ministry, Orleans was persuaded by Mirabeau to offer his services as mediator between the king and his rebellious subjects; but to stipulate, at the same time, for his appointment to the high office of lieutenant-general of the kingdom as necessary to give his mediation due weight with the rebels. The real object of the profligate Count, in this dangerous proposal, and which he did not deign even to conceal, was to pave the way for the infamous Duke stepping into the throne of his relation and virtuous sovereign. He even went so far as to compose the speech with which Orleans was to address the king on the occasion; but that coward, when he arrived at the palace, was so embarrassed by the consciousness of his own wicked designs, that instead of asking the office of lieutenant-general, he only requested permission to retire into England!! A request which was instantly granted.

This brought upon him the contempt and indignation of Mirabeau; but still there was a party desirous of placing him on the throne. This we think evident from an atrocious [illegible] mentioned in all the journals, and confirmed by M. Bertrand. When the king, on his first visit to Paris (See nº [illegible]) [illegible] the *Champ Elisées*, three or four guns were fired at once. It was never known whence they proceeded; but it is certain that an unfortunate woman in the crowd, who was in the direction of his Majesty's carriage, was shot at the time, and fell dead on the spot. As the King's carriage held at the time [illegible] four persons, M. Bertrand very naturally con[illegible]es that these four shots, fired at once in its direction, had been ordered and paid for; and we are unwilling to believe that at that period of the revolution there was any party disposed to pay for the murder of the sovereign but the Duke of Orleans and his infamous adherents. That he was equal to this wickedness cannot be doubted, when it is known that legal evidence was afterwards produced that he, with some other members of the Assembly, secretly directed the insurrection of the 5th of October, and promoted the outrages of that and the succeeding day by the distribution of money and bread *.

413 M. Memmay vindicated. We have said (nº 48.), the origin of the report of a train of gunpowder being laid by M. de Memmay, to blow into the air a number of patriots, has never been well explained. It was proved judicially, that at the period when the feast was given by M. Memmay to the inhabitants of Vesoul, he was setting vines in a stony soil, where he was often obliged to blow up the greater rocks. Some soldiers running through, and ferreting every where in the house and out-houses, unfortunately took a candle to the dark corner where the barrel of gunpowder was lodged, and set it on fire, in trying to see if it contained wine. These facts, reported and attested in a memorial drawn up by M. Courvoisier, so completely justified M. de Memmay, that the Assem-

* Bertrand's Annals, vol. ii. ch. 13.

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414 The power of the assembly in danger of being recalled by its constituents. In n° 70. we have said that the National Assembly, after its removal from Versailles to Paris, was in tolerable security; but M. Bertrand has proved, by evidence the most incontrovertible, that it did not think itself secure; and that if the ministers had been capable of employing events to their own advantage, the powers of that factious body must have been recalled by its own constituents. The horrible outrages committed on the 5th and 6th of October had shocked all France. The wanton confiscation of the property of the church, had demonstrated to every man of sound judgment, that under the new order of things no property could be secure; and by the desertion of its more virtuous and moderate members, the Assembly had become *a rump assembly*. It was therefore much alarmed when the intermediate commission of the states of Cambresis entered, on the 9th of November, into a resolution, in which, considering—"that certain decrees of the National Assembly are paving the way for the ruin of the kingdom, and the annihilation of religion; that if they have been able to place one species of property at the disposal of the nation, men of all kinds of property may expect the same fate; they declare, from this moment, the power of the deputies of Cambresis to the National Assembly to be null and revoked." Had M. Necker and his colleagues had address to get similar resolutions entered into at the same time by the electors of all the bailiwicks of the kingdom, the Assembly must have been dissolved, and France, even then, might have been saved; but those ministers were themselves nothing more than the humble and docile agents of the Assembly.

415 Account of the red book. [illegible]ere is no part of our former narrative more incor[illegible] or more likely to mislead the public, than our ac[illegible] of the *red-book* (n° 75.). It is such, however, [illegible] without any addition or aggrava[illegible] [illegible]lains (x) who, in direct contradic[illegible] their own solemn promise, as well as to every principle of honour, made part of that book public, had the impudence to affirm, that, by the suppression of the superfluous pensions registered in it, a saving would be made to the public *of near a fifth in the bulk of the expences of every year*. M. Bertrand, taking for granted the accuracy of their statements, for the exaggeration of which, however, he urges arguments more than plausible, proves, if arithmetical calculation affords proof, that by the suppression of such pensions as even *they* called superfluous, the saving in the bulk of the annual expences could not possibly have amounted to more than *the two hundredth part!* It was not therefore without reason that M. Necker, in answer to their publication, said, "I know not whether the books of the finances of any sovereign in Europe can shew a similar total."

416 And of the mutiny at Nancy. Our account of the mutiny of the soldiers at Nancy (n° 83.) is very inaccurate. Far from being excited by the officers, that mutiny was the natural consequence of the absurd decrees of the Assembly; which having declared *all men equal*, and made it criminal to punish disobedient soldiers in that summary way, without which no armed force can be commanded, had completely disorganised the army, and substituted for martial law patriotic exhortations, legislative decrees, and the novel jurisdiction of municipalities. The soldiers knew their own strength, of which indeed they were continually informed by the friends of the revolution; and while they shook off the authority of their military commanders, they laughed at the impotent decrees of the Assembly. At Nancy they had imprisoned two general officers, and committed other outrages of the most serious nature. It was the duty of the Marquis de Bouillé, as governor of the province, to reduce the insurgents by force, if force should be found necessary; but he had accomplished his object without shedding blood, and was congratulating the two liberated generals, and some of the principal inhabitants, upon so happy a termination of the affair, when the populace, and many soldiers who had not followed their colours, fired upon the troops under his command, and killed fifty or sixty men. The troops immediately returned the fire; and a great number of the rebellious mob and mutinous garrison were of course put to the sword. That such able and firm conduct in Bouillé excited indignation among the Jacobins of Paris, is very probable; but even the king himself did not express higher approbation of it than the National Assembly, who were duly sensible that it saved themselves from destruction, which, had he failed in his enterprise, would have been inevitable. Three months afterwards, indeed, when the fabrication of counter-revolutionary plots became part of the daily business of this enlightened Assembly, some censures were thrown by the Jacobins upon the Marquis's conduct on this occasion; and those censures were loudly applauded.

417 M. de Bouillé vindicated. We have likewise been led, by our fallacious guides, to accuse this gallant officer (n° 91.) of having laid open the country to the inroads of foreign armies; and we have given an incorrect account of the king's flight from Paris. There is no evidence whatever for the truth of the charge against the Marquis de Bouillé, and it is directly contrary to his general character. He was indeed a royalist, and would doubtless have cooperated with the Prince of Condé and the other emigrants in restoring the king to his lawful authority; but he was likewise a Frenchman and a patriot in the best sense of the word; and he would have died in defence of the rights and independence of his country. He certainly meant to protect the king in his journey from Paris to Montmedi, where it was to terminate; and he had stationed troops of dragoons on the road for that purpose; but the unfortunate Louis had delayed his journey a day longer than was agreed upon; and even when he set out, neglected to send couriers before him to warn the troops of his approach. He thus travelled unprotected; and the consequence was such as we have related. Yet the gallant Bouillé, tho' this journey was undertaken contrary to his advice, declared himself the author of it, in that letter in which he threatened the Assembly with vengeance of all Europe

(x) These were the Marquis de Montcalm-Gozon, Baron Felix de Wimpfen, de Menou, Fieteau, L. M. de Lepeaux, the Abbé Expilly, Camus, Goupil de Prefeln, Gautier de Biauzat, Treilhard, Champeaux-Palasne, and Cottin.

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rope if they should dare to touch a hair of the heads of the royal family.

418 Erroneous account in n° 90. corrected.

In n° 90. we have most unaccountably said that the king was permitted to continue his journey to St Cloud. This is directly contrary to truth. The president, after hearing his complaint against those who had prevented it, replied indeed in a speech, containing some expressions of gratitude and affection, mixed with reflections on the refractory priests; but the Assembly determined nothing respecting the propriety of the journey. They did not even suffer a single motion to be made on the subject; and threatened with imprisonment one of the members who proposed to take it into consideration! The king was therefore obliged to abandon this excursion, though it was first undertaken from religious motives; and it was then that he seriously thought of attempting to elude the vigilance of his rebellious guards, and of taking up his residence at Montmedi.

419 Treaty of Pavia a forgery.

In n° 96. we have published, with doubts indeed of its authenticity, what was called the *treaty of Pavia* and the *convention at Pilnitz*. The terms in which we introduced that scandalous fabrication to the notice of our readers, and the principles which we have uniformly avowed through the whole of this voluminous work, furnish, we hope, sufficient evidence that we could have no intention to deceive the public. Truth, however, demands of us to acknowledge, in the most explicit terms, that the pretended treaty of Pavia is not only a forgery, but a bungling forgery, defective in some of the most usual diplomatic forms; and that the conferences at Pilnitz between the Emperor, the King of Prussia, and the Count d'Artois, related to objects very different from a partition of the French territories.

So early as the month of May 1791, a plan had been digested by the Emperor, the King of Prussia, and the King of Spain, with the concurrence of Louis XVI. for liberating that unfortunate monarch from the confinement in which he was kept in his own capital. The means to be employed were a coalition among the principal powers on the continent to lead armies in every quarter to the borders of France. During the alarm which so menacing an appearance could not but excite in that kingdom, a declaration by the house of Bourbon, complaining of the cruel and iniquitous treatment of its head, was to be circulated through France, and to be immediately followed by the manifesto of the combined powers. This, it was presumed, would furnish a sufficient reason, even to the National Assembly, for the king's going to the frontiers, and placing himself at the head of the army; but if it should not, petitions were to be procured from the army and the provinces, requesting his presence, as the only means left of preventing a civil as well as foreign war. Had this measure, which was partly suggested by Mirabeau and partly by Montmorin and Calonne, been steadily pursued, there can be little doubt but it would have proved completely successful. It was defeated, however, by the king's ill-concerted attempt to escape to Montmedi, and by a very imprudent and degrading letter which he was afterwards persuaded to send to every foreign power.

420 Real convention at Pilnitz.

At Pilnitz, where the Emperor and the King of Prussia met, on the 25th of August, to settle between themselves some interests too delicate to be adjusted by the usual diplomatic modes, an agreement was entered into by them to support the cause of the French princes, to liberate the king, and to save, if possible, the monarchy. They delivered, accordingly, to the Count d'Artois the following declaration:

"His Majesty the Emperor, and his Majesty the King of Prussia, having heard the desires and the representations of Monsieur and his Royal Highness the Count d'Artois, declare, conjointly, that they consider the situation in which his Majesty the King of France is at present placed, as a matter which concerns the interest of every sovereign of Europe.—They hope that that interest will not fail to be acknowledged by the powers whose assistance is required; and that consequently they will not refuse to employ, in conjunction with their Majesties, the most efficacious means, according to their abilities, to put the King of France in a situation to establish, in perfect liberty, the foundations of a monarchical government, equally agreeable to the rights of sovereigns and the welfare of the French; then, and in that case, their Majesties are determined to act promptly and by mutual consent, with the forces necessary to obtain the end proposed by all of them. In the mean time they will give orders for their troops to be ready for actual service.

"*Pilnitz, August 27th, 1791.*

"Signed by the Emperor and the King of Prussia."

Such was the agreement entered into at Pilnitz, which was so grossly misrepresented by the French Jacobins, and by their zealous partizans in this country. Had not Lou[illegible]
and uncondit[illegible]
might have been[illegible]
and the prese[illegible]
ceptance, so little[illegible]
powers, completely[illegible] jes;
and before their armies[illegible]
narchy was overturned.

421 The Fre[illegible] the aggres[illegible] in the [illegible] with Britain.

In our account of the [illegible]
Great Britain an[illegible]
ved, by evidence[illegible]
that the French regi[illegible]
the British ministry[illegible] be[illegible]
ently with the independence of their own country, to maintain the relations of amity between the two nations. That we have interpreted fairly that decree of the Convention by which this kingdom was forced into the war, is rendered incontrovertible by a subsequent decree on the 15th of December, by which their generals were ordered to regulate their conduct in the countries which their armies then occupied, or *might afterwards occupy*. In the preamble to this decree, they expressly declared, that *their principles would not permit them to acknowledge any of the institutions militating against the sovereignty of the people*; and the various articles exhibit a complete system of demolition. They insist on the immediate *suppression of all existing authorities*, the *abolition of rank and privilege* of every description, and the *suppression of all existing imposts*. Nay, these friends to freedom even declare, that they will treat as enemies *a whole nation* (un peuple entier) which shall presume to *reject liberty and equality*, or enter into *a treaty with a prince or privileged casts!*

It is worthy of remark, that *the very day* on which this decree, containing a systematic plan for disorganizing all lawful governments, passed the Assembly, the provi-

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provisional executive council wrote to their agent, Chauvelin, instructing him to disavow all hostile intentions on the part of France, and to proclaim her detestation of the idea of a war with England! Yet the same provisional council, in their comments on the 11th article of this decree, thus express themselves: "The right of natural defence, the duty of securing the preservation of our liberty, and the success of our arms, the universal interest of restoring to Europe a peace, *which she cannot obtain but by* THE ANNIHILATION OF THE DESPOTS *and their satellites*, every thing imposes on us the obligation of exercising all the *rigours of war*, and the *rights of conquest*, towards a people so fond of their chains, so obstinately wedded to their degradation, as to refuse to be restored *to their rights*, and who are the accomplices, not only *of their own despots*, but even of all the *crowned usurpers*, who divide among themselves the dominion of the earth and its inhabitants." That Britain is one of those countries which the assembly thought their armies might afterwards occupy, and that the great majority of Britons were a people towards whom their principles obliged them to exercise all the rigours of war, and the rights of conquest, is evident from the following extract of a letter, written on the 31st of December 1792, by Monge, a member of the council, and minister of the marine to the sea-ports. "The King and his [illegible] war upon us. Will the [illegible]? Already [illegible] and the repug[illegible] against *their* [illegible] to their suc[illegible] island; we will [illegible] will plant there [illegible] our arms to our [illegible] *of their govern*[illegible]

[illegible] November and December [illegible] object is [illegible] executive [illegible] marine, [illegible] adopt as [illegible] and de Molleville*. [illegible] but perspicuous view of the rise and progress of that revolution, or, to speak more correctly, that series of revolutions which has for seven long years oppressed, not France alone, but all Europe, we shall conclude this long article.

* Introduction to the *Annals of the French Revolution*.

Rise and progress of the revolution.

"Popular [illegible], and an army (says this able and useful [illegible]) [illegible] hitherto been the usual means, or chief instruments, of every revolution; but those insurrections being of the most ignorant and unthinking class of the people, were always fomented by a certain number of factious men, devoted to, and dependent upon, some ambitious chief, daring, brave, of military talents, sole and absolute conductor of every step of the revolt, and master of all the means of the insurrection. In the hands of this chief, the soldiers, or people armed, were but machines, which he set in motion or restrained according to his pleasure, and of which he always made use to put an end to revolutionary disorders and crimes, as soon as the object of the revolution was gained. So Cæsar and Cromwell, after they had usurped the supreme power, lost no time in securing it to themselves, by placing it on the basis of a wise and well-regulated government; and they employed, in quelling the troubles that had favoured their usurpation, those very legions, that same army, which they had used to excite them.

"This was not the case in France: there, the revolution, or rather the first of those it experienced, and of which the others were the inevitable consequence, was not, whatever be supposed, the result of a conspiracy, or preconcerted plan, to overturn the throne, or to place an usurper upon it. It was unexpectedly engendered by a commixture of weakness, ignorance, negligence, and numberless errors in the government. The States General, however imprudent their convocation may have been, would have produced only useful reforms, if they had found the limits of their power marked out by a hand sufficiently firm to have kept them within that extent. It was, however, but too evident that, even before their opening, they were dreaded, and that consequently they might attempt whatever they pleased. From that time, under the name of *Clubs*, various associations and factions sprang up; some more violent than others, but all tending to the subversion of the existing government, without agreeing upon the form of that which was to be substituted: and at that juncture also the projects of the faction, whose views were to have the Duke of Orleans appointed lieutenant-general of the kingdom, began to appear.

"This faction, or more properly this conspiracy, was indeed of the same nature as those that had produced all former revolutions, and might have been attended with the same consequences, had the Duke of Orleans been possessed of that energy of character, that bravery and daring spirit, requisite in the leader of a party. The people had already declared in his favour, and he might very easily have corrupted and brought over a great part of the army, had he been equal to the command of it: but, on the very first occasion of personal risk, he discovered such cowardice and meanness, that he defeated his own conspiracy, and convinced all those who had entered into it, that it was impossible to continue the revolution, either in his favour or in conjunction with him. The enthusiasm the people had felt for him ended with the efforts of those who had excited it.

"Mr Necker, whom the multitude had associated with him in their homage, still preserved for some time his adorers, and that little cabal which was for ever exalting him to the skies. But as he was inferior even to the Duke of Orleans in military talents and dispositions, he was as little calculated to be the leader of a revolution, or of a great conspiracy: for which reason his panegyrists then confined themselves in their pamphlets and placards, with which the capital was overrun, to insinuating, that the only means of saving the state was to declare Mr Necker *Dictator*; or at least to confer upon him, under some title more consistent with the monarchy, the authority and powers attached to that republican office. In fact, if after his dismission, in the month of July 1789, he had dared to make this a condition of his return to the ministry, it is more than probable that the king would have been under the necessity of agreeing to it, and perhaps of re-establishing in his person the office of mayor of the palace. At that moment he might have demanded any thing: eight days later, he might have been refused every thing: and

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and very soon after, he was reduced to sneak out of the kingdom, in order to escape the effects of the general contempt and censure which he had brought upon himself.

"General La Fayette, who then commanded the Parisian National Guard, gathered the wrecks of all this popularity, and might have turned them to the greatest advantage, if he had possessed 'that resolute character and heroic judgment' of which Cardinal de Retz speaks, and 'which serves to distinguish what is truly honourable and useful from what is only extraordinary, and what is extraordinary from what is impossible.' With the genius, talents, and ambition of Cromwell, he might have gone as great a length; with a less criminal ambition, he might at least have made himself master of the revolution, and have directed it at his pleasure: in a word, he might have secured the triumph of whatever party he should have declared himself the leader. But as unfit for supporting the character of Monk as that of Cromwell, he soon betrayed the secret of his incapacity to all the world, and was distinguished in the crowd of constitutional ringleaders only by his three-coloured plume, his epaulets, white horse, and famous saying—'Insurrection is the most sacred of duties when oppression is at its height.'

"The revolution, at the period when the faction that had begun it for the Duke of Orleans became sensible that he was too much a coward to be the leader of it, and when La Fayette discovered his inability to conduct it, was too far advanced to recede or to stop; and it continued its progress, but in a line that no other revolution had taken, viz. without a military chief, without the intervention of the army, and to gain triumphs, not for any ambitious conspirator, but for political and moral innovations of the most dangerous nature; the most suited to mislead the multitude, incapable of comprehending them, and to let loose all the passions. The more violent combined to destroy every thing; and their fatal coalition gave birth to Jacobinism, that terrible monster till then unknown, and till now not sufficiently unmasked. This monster took upon itself alone to carry on the revolution; it directed, it executed, all the operations of it, all the explosions, all the outrages: it every where appointed the most active leaders, and, as instruments, employed the profligates of every country. Its power far surpassed that which has been attributed to the inquisition, and other fiery tribunals, by those who have spoken of them with the greatest exaggeration. Its centre was at Paris; and its rays, formed by particular clubs in every town, in every little borough, overspread the whole surface of the kingdom. The constant correspondence kept up between those clubs and that of the capital; or, to use their own expression, *des Sociétés populaires affiliées avec la Société mere*—'between the affiliated popular Societies and the parent Society,' was as secret and as speedy as that of free-masons. In a word, the Jacobin clubs had prevailed in causing themselves to be looked up to as the real national representation. Under that pretence, they censured all the authorities in the most imperious manner; and whenever their denunciations, petitions, or addresses, failed to produce an immediate effect, they gained their point by having recourse to insurrection, assassination, and fire. While Jacobinism thus subjected all France to its controul, an immense number of emissaries propagated its doctrines among foreign nations, and prepared new conquests for it.

"The National Assembly, the capital, indeed we may say all France, was divided into three very distinct parties. The most considerable in number, but unhappily the weakest through a deficiency of plan and resolution, was the party purely Royal: it was adverse to every kind of Revolution, and was solely desirous of some improvements, with the reform of abuses and pecuniary privileges:—the most able, and most intriguing, was the Constitutional party, or that which was desirous of giving France a new monarchical constitution, but modified after the manner of the English, or even the American, by a house of representatives. The third party was the most dangerous of all, by its daring spirit, by its power, and by the number of proselytes it daily acquired in all quarters of the kingdom: it comprised the Democrats of every description, from the Jacobin clubs, calling themselves *Friends of the Constitution*, to the anarchs and robbers.

"The Democratic party, which at first was only auxiliary to the Constitutional one, in the end annihilated it, and became itself subdivided into several other parties, whose fatal struggles produced the subsequent revolutions, and may still produce many more. But in principle, the Constitutionalists and the Democrats formed two distinct, though confederate, factions; both were desirous of a revolution, and employed all the usual means of accomplishing it, except troops, which could be of no use to them, for neither of them had a leader to put at the head of the army. But as it was equally of importance to both that [illegible] be deprived of the power of [illegible] they laboured in concert to disorganise [illegible] complete success of that manœuvre was [illegible] ved by the fatal issue of the departure of the royal family for Montmedi. The revolution [illegible] daring and rapid stride, which was [illegible] pretended constitution act of 1791 [illegible] of its principles, and the defects of its [illegible], present a faithful picture of the division of its authors, and of the opposite interests by which they were swayed. It was, properly speaking, a compact between the faction of the Constitutionalists and that of the Democrats, in which they mutually made concessions and sacrifices.

425 Constitution of 1791 completes the first revolution.

"Be that as it may, this absurd constitution, the everlasting source of remorse or sorrow to all who bore part in it, might have been got over without a shock, and led back to the old principles of monarchical government, if the Assembly who framed it had not separated before they witnessed the execution of it; if, in imposing on the king the obligation to maintain it, they had not deprived him of the power and the means; and above all, if the certain consequence of the new mode of proceeding at the elections had not been to secure, in the second Assembly, a considerable majority of the Democratic against the Constitutional party.

"The second Assembly was also divided by three factions, the weakest of which was the one that wished to maintain the constitution. The other two were for a new revolution and a republic; but they differed in this, that the former, composed of the Brissotins and Girondists, was for effecting it gradually, by beginning with divesting the king of popularity, and allowing the public

public mind time to wean itself from its natural attachment to monarchy; and the latter, which was the least numerous, was eager to have the republic established as soon as possible. These two factions, having the same object in view, though taking different roads, were necessarily auxiliaries to each other; and the pamphlets, excitations to commotion, and revolutionary measures of both, equally tended to overthrow the constitution of 1791.

"Those different factions, almost entirely composed of advocates, solicitors, apostate priests, doctors, and a few literary men, having no military chief capable of taking the command of the army, dreaded the troops, who had sworn allegiance to the constitution, and obedience to the king, and who moreover might be influenced by their officers, among whom there still remained some royalists. [illegible]
on t [illegible]
the [illegible]
cessary, [illegible]
council were equally averse. No more was wanting to determine the attack which was directed, almost at the same time, against all the ministers, in order to compel them to retire, and to put the king under the necessity of appointing others more disposed to second the views of the parties. Unhappily this attempt was attended with all the success they had promised themselves; and [illegible] s of the new ministry was to declare [illegible] the same time, the emi- [illegible] and which was almost [illegible] the lowest class of peo- [illegible] of the royal party, [illegible] of [illegible] best defenders, expo- [illegible] and insults that sprang from innu- [illegible] for which the disasters at the be- [illegible] but too many opportu- [illegible]

[illegible] and accelerated the new [illegible] on the 10th of Au- [illegible] nment of the [illegible] tion of the consti- [illegible] 1. The latter, ho[we]ver, was not entirely abandoned on that day; for the project of the Girondists, who had laid the plot of that horrible conspiracy, was then only to declare the king's deposition, in order to place the prince royal upon the throne, under the guidance of a regency composed of their own creatures; but they were hurried away much farther than they meant to go, by the violence with which the most furious of the Jacobins, who took the lead in the insurrection, conducted all their enterprises. The prince royal, instead of being crowned, was shut up in the Temple; and if France at that moment was not declared a republic, it was less owing to any remaining respect for the constitution, than to the fear the legislative body was in of raising the army against it, and also the majority of the nation, who would naturally be angry to see a constitution which seemed to be rendered secure and stable by so many oaths, thus precipitately overthrown, without their having been consulted.

[illegible] revolution.

"It was on these considerations that the opinion was adopted, that a National Convention should be convoked, to determine the fate of royalty. Prompt in seizing all the means that might ensure the success of this second revolution, the Assembly, under pretence of giving every possible latitude to the freedom of elections, decreed, that all its members should be eligible for the National Convention.

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"From that moment the Girondists daily lost ground, and the most flaming members of the Democratic party, supported by the club of Jacobins, by the new Commune of Paris, and by the Tribunes, made themselves masters of every debate. It was of the utmost importance to them to rule the ensuing elections; and this was secured to them by the horrible consternation which the massacres of the 2d of September struck throughout the kingdom. The terror of being assassinated, or at least cruelly treated, drove from all the Primary Assemblies, not only the royalists and constitutionalists, but moderate men of all parties. Of course, these assemblies became entirely composed of the weakest men [illegible]

[illegible] legislative body. Accordingly, this third Assembly, in the first quarter of an hour of their first sitting, were heard shouting their votes for the abolition of royalty, and proclaiming the republic, upon the motion of a member who had formerly been a player.

"Such an opening but too plainly shewed what was to be expected from that horde of plunderers which composed the majority of the National Convention, and of whom Robespierre, Danton, Marat, and the other ringleaders, formed their party. That of the Brissotins and Girondists still existed, and was the only one really republican. These semi-wretches, glutted with the horrors already committed, seemed desirous of arresting the torrent of them, and laboured to introduce into the Assembly the calm and moderati[on] that were necessary to give the new republic a wise and solid organization. But the superiority of their knowledge, talents, and eloquence, which their opponents could not dispute, had no power over tigers thirsting for blood, who neither attended to nor suffered motions but of the blackest tendency. No doubt they had occasion for atrocities upon atrocities to prepare the terror-struck nation to allow them to commit, in its name, the most execrable of all, the murder of the unfortunate Louis XVI: and that martyrdom was necessary to bring about a third revolution, already brewing in the brain of Robespierre. Fear had greatly contributed to the two former: but this was effected by terror alone, without popular tumults, or the intervention of the armies; which, now drawn by their conquests beyond the frontiers, never heard any thing of the revolutions at home, till they were accomplished, and always obeyed the prevailing faction, by whom they were paid.

427 The third revolution.

"By the degree of ferocity discovered by the members of the Convention in passing sentence upon the king, and in the debates relative to the constitution of 1793, Robespierre was enabled to mark which of the deputies were likely to second his views, and which of them it was his part to sacrifice.

"The people could not but with transport receive a constitution which seemed to realise the chimera of its sovereignty, but which would only have given a kind of construction to anarchy, if the execution of this new code had not been suspended under the pretext, belonging in common to all acts of despotism and tyranny, of *the supreme law of the safety of the state.* This suspension

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sion was effected, by establishing the Provisionary Government, which, under the title of Revolutionary Government, concentrated all the powers in the National Convention until there was an end to the war and all intestine troubles.

" Although the faction, at the head of which Robespierre was, had a decided majority in the Assembly, and might consequently have considered themselves as really and exclusively exercising the sovereign power, he was a demagogue of too despotic a nature to stomach even the appearance of sharing the empire with so many co-sovereigns. He greatly reduced their number, by causing all the powers invested in the National Assembly by the decrees that had established the revolutionary government, to be transferred to a committee, to which he got himself appointed, and where he was sure of the sole rule, by obtaining for colleagues men less daring than himself, though equally wicked; such as Couthon, St Just, Barrere, and others like them. This committee, who had the assurance to style themselves the *Committee of Public Safety*, very soon seized upon both the legislative and executive powers, and exercised them with the most sanguinary tyranny ever yet heard of. The ministers were merely their clerks; and the subjugated Assembly, without murmur or objection, passed all the revolutionary laws which were proposed, or rather dictated, by them. One of their most horrible and decisive conceptions was that of those Revolutionary Tribunals which covered France with scaffolds, where thousands of victims of every rank, age, and sex, were daily sacrificed; so that no class of men could be free from that stupefying and general terror which Robespierre found it necessary to spread, in order to establish and make his power known. He soon himself dragged some members of his own party, such as Danton, Camille des Moulins, and others, whose energy and popularity had offended him, before one of those tribunals, where he had them condemned to death. By the same means he got rid of the chief leaders among the Brissotines and Girondists; while he caused all the moderate republican party who were still members of the Assembly, except those who had time and address to escape, to be sent to prison, in order to be sentenced and executed on the first occasion.

416 The fourth revolution produces

" In this manner ended the third revolution, in which the people, frozen with terror, did not dare to take a part. Instead of an army of soldiers, Robespierre employed an army of executioners and assassins, set up as revolutionary judges; and the guillotine, striking or menacing all heads indiscriminately, made France, from one end to the other, submit to him, by the means of terror or of death. Thus was this nation, formerly so proud, even to idolatry, of its kings, seen to expiate, by rivers of blood, the crime of having suffered his to be spilt who was the most virtuous of all their monarchs.

" In the room of that famous Bastile, whose celebrated capture and demolition had set only seven prisoners at liberty, two of whom had been long in a state of lunacy, the colleges, the seminaries, and all the religious houses of the kingdom, were converted into so many state prisons, into which were incessantly crowded, from time to time, the victims devoted to feed the ever-working guillotines, which were never suffered to stand still for a day, because they were at once the chief resource of supplies for the government, and the instrument of its ferocity. ' The guillotine coins money for the republic,' was said in the tribune by one of Robespierre's vilest agents *. In fact, according to the jurisprudence of the Revolutionary Tribunals, the rich of every class, being declared suspected persons, received sentence of death, for no other reason than that of giving the confiscation of their property a show of judicial form.

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* Barrere.

" Still blood flowed too slowly to satisfy Robespierre; his aim was but partly attained by the proscription of the nobles, the priests, and the wealthy. He fancied, not only an aristocracy of talents and knowledge, but of the virtues, none of which would his trusty orators and journalists admit, save that horrid *patriotism* which was estimated according to the enormity of the crimes committed in favour of the revolution. His plan was to reduce the French people to a mere plantation of slaves, too ignorant, too stupid, or too pusillanimous, to conceive the idea of breaking the chains with which he would have loaded them in the name of liberty; and he might have succeeded in it, had not his ambition, as impatient as it was jealous, too soon unveiled the intention of resorting to the guillotine to strike off the shackles with which an assembly of representatives of the nation fettered, or might fetter, his power. He was about to give this decisive blow, which he had concerted with the Commune of Paris, the Revolutionary Tribunal, the Club of [illegible] cers of the Natio[illegible] Convention, who [illegible] sced, anticipated [illegible] pected it, by attacking [illegible] energy sufficient to rouse all [illegible] against him and against the Jacobins [illegible] blows, and victory remained [illegible] but at length declared against Robespierre [illegible] of a day, that execrable monster was [illegible] highest pitch of power [illegible] the very scaffold that [illegible] of his last victims. [illegible] Committee of Public Safety [illegible] National Guard, in [illegible] many of his agents in the provinces, met the same fate. The Revolutionary Tribunals were suppressed, and the prisons thrown open to all whom they had cast into them.

427 The constitution of 1795.

" This fourth revolution, in which the faction then esteemed the moderate party overthrew the terrorists, and seized the supreme power, was no less complete than those which had preceded it, and produced the constitution of 1795. All France received as a great blessing a constitution that delivered them from the revolutionary government and its infernal policy. Besides, it had, in spite of great defects, the merit of coming nearer than the two preceding ones, to the principles of order, of justice, and real liberty; the violation of which had, for five years before, been the source of so many disasters and so many crimes. The royalists, considering it as a step towards monarchy, were unfortunately so imprudent as to triumph in it; and their joy, as premature as indiscreet, alarmed the Assembly to such a degree, that they passed the famous law, ordaining the Primary Assemblies to return two-thirds of the members of the Convention to the legislative body, which

French Revolution. was to succeed that assembly. It was thus that the spirit of the Convention continued, for the first year, to be displayed in the two councils.

"In the year following, the bias of the public mind, perhaps too hastily turned towards royalty, shewed itself in the elections of the members for the new third, so clearly as to alarm the regicides who composed the Directory, and the Conventionalists, who still made a third of the legislative body; nor did they lose a moment in devising means for their defence. That which appeared the surest to them was, to publish notices of plots among the royalists, and annex one or more denunciations, in terms so vague as to leave room for implicating, when necessary, all their adversaries; while by the help of this imposture they procured some secret information, artfully fabricated, and ever easily obtained through threats or rewards by those who have at command the guillotine and the public treasure.

"This masked battery was ready to be opened before the members of the new third took their seats. These at first confined themselves to the securing of a constant majority in the two councils in favour of the moderate opinions; but in a little time every sitting was marked by the repeal of some revolutionary law, or by some decree tending to restrain the executive authority within the limits fixed by the constitution.

428 The fifth revolution. "The Directory [illegible] of their power, and dreading [illegible] attacks upon it, came to a [illegible] postponing the blow they [illegible] the legislative assembly [illegible] in it [illegible] as any of those [illegible] It differed indeed from [illegible] facility and promptness with [illegible] although the party which pre- [illegible] the majority of the Directory, and [illegible] Legislative Body, had to combat [illegible] but against the opi- [illegible] of the public. [illegible] majority of the two [illegible] vanish- ed [illegible] force of a detach- [illegible] hundred men; [illegible] that the power of the public opinion, ridiculously exaggerated in these days, is and can be no more, under a firm and well ordered government, than a mere fancy. Men accustom themselves too easily to take for public opinion the private opinions made public by certain writers, whose caution or audaciousness depends always upon the energy or feebleness of the supreme authority. It is the same thing with popular commotions: they are easily excited under a weak government, which does not possess the wisdom to prevent or the spirit to suppress them; but a vigorous, just, and strict government has nothing to fear from them. The Directory, compelled to withdraw the larger body of troops, which they had thought necessary to ensure the revolution they were meditating, discovered, no doubt, great ability in securing the two councils, by appearing to dread them: but it was chiefly to the energy of their measures, and to the concentration and promptness with which they were executed, that they owed their success. Two days before, the legislative body might, without obstruction, have impeached, arrested, and even outlawed, the majority of the Directory, who were execrated by the public under the title of Triumvirate; and, if requisite, they would have been supported by more than 30,000 armed citizens, who, with Pichegru and Villot at their head, would soon have dispersed, and perhaps brought over, the feeble detachments of troops of the line which the Directory had at their command. The legislative body, relying too much upon its popularity, did not sufficiently consider, that the people, whose impetuosity is commonly decisive when allowed to take advantage in attack, are always feeble on the defensive, and totally unable to withstand every assault made previous to an insurrection, for it is always easy to prevent their assembling. It was on this principle that the Directory founded their operations, and the 5th of September too well proves how justly. That day reduced the legislative body, by the most degrading subjugation, to a mere disgusting caricature of national representation; it invested the Directory with the most arbitrary and tyrannic power, and restored the system of Robespierre, under a form less bloody, but not less pernicious; for the Revolutionary Tribunals which that monster had established, were scarcely more expeditious than the military ones of the Directory. The power of arbitrary and unlimited transportation is, in time, as destructive as the guillotine, without possessing, like that, the advantage of exciting a salutary horror, which, by recovering the people from the state of stupor and apathy, the constant effects of terror, gives them both recollection and force to break their chains. Though, in violating the most essential regulations of the constitution, the Directory obtained a temporary confirmation of their power, their example pointed out to Bonaparte and Sieyes the path which they pursued with infinite address, and in which they accomplished a sixth revolution." 429 The sixth revolution, and consular government.

How long the consular government will continue, it is impossible to conjecture; but we may, without presumption, venture to predict, that it cannot be permanent. To the Jacobins and original constitutionalists it must be more obnoxious than the old government; because Bonaparte is more despotic than was Louis XIV; and the royalists, though they may prefer the vigorous and comparatively mild government of one man, whose talents are indisputable, to the ferocious tyranny of the lowest of the rabble, must look with indignation at a foreign adventurer seated on the throne of their ancient monarchy.

RHABDOLOGY, or Rabdology, in arithmetic, a name given by Napier to a method of performing some of the more difficult operations of numbers by means of certain square little rods. Upon these are inscribed the simple numbers; then by shifting them according to certain rules, those operations are performed by simply adding or subtracting the numbers as they stand upon the rods. See Napier's *Rabdologia*, printed in 1617. See also the article Napier's *Bones*.

RHOMB Solid, consists of two equal and right cones joined together at their bases.

RICE (see that article, and Oryza, *Encycl.*) is strongly recommended, in a late publication, as the best corrective of *sprit* flour, of which there is a great quantity in Scotland every year, and of course a great deal of unpleasant and unwholesome bread. The gentleman, who writes the short paper alluded to, directs ten pounds of flour and one pound of ground rice, with the usual

usual quantity of yest, to be placed, for about two hours, before a fire, and then formed into bread in the common way. This addition of rice, besides correcting the bad qualities of the damaged flour, adds, he says, much to its nutriment: and he is undoubtedly right; for the flour of rice, though very nutritious, is so dry, that it is difficult to make bread of it by itself. See *Bread of Rice*, in this *Suppl.*

As rice is a favourite substitute for bread in years of scarcity, it may not be disagreeable to our readers to know the method of cultivating the plant in those countries where it is the principal food of the inhabitants. We have the following full and perspicuous account of the Chinese practice by Sir George Staunton.

"Much of the low grounds in the middle and southern provinces of the empire are appropriated to the culture of that grain. It constitutes, in fact, the principal part of the food of all those inhabitants, who are not so indigent as to be forced to subsist on other and cheaper kinds of grain. A great proportion of the surface of the country is well adapted for the production of rice, which, from the time the seed is committed to the soil till the plant approaches to maturity, requires to be immersed in a sheet of water. Many and great rivers run through the several provinces of China, the low grounds bordering on those rivers are annually inundated, by which means is brought upon their surface rich mud or mucilage that fertilizes the soil, in the same manner as Egypt receives its fecundative quality from the overflowing of the Nile. The periodical rains which fall near the sources of the Yellow and the Kiang rivers, not very far distant from those of the Ganges and the Burumpooter, among the mountains bounding India to the north, and China to the west, often swell those rivers to a prodigious height, though not a drop of rain should have fallen on the plains through which they afterwards flow.

"After the mud has lain some days upon the plains in China, preparations are made for planting them with rice. For this purpose, a small spot of ground is inclosed by a bank of clay; the earth is ploughed up; and an upright harrow, with a row of wooden pins in the lower end, is drawn lightly over it by a buffalo. The grain, which had previously been steeped in dung diluted with animal water, is then sown very thickly on it. A thin sheet of water is immediately brought over it, either by channels leading to the spot from a source above it, or when below it by means of a chain pump, of which the use is as familiar as that of a hoe to every Chinese husbandman. In a few days the shoots appear above the water. In that interval, the remainder of the ground intended for cultivation, if stiff, is ploughed, the lumps broken by hoes, and the surface levelled by the harrow. As soon as the shoots have attained the height of six or seven inches, they are plucked up by the roots, the tops of the blades cut off, and each root is planted separately, sometimes in small furrows turned with the plough, and sometimes in holes made in rows by a drilling stick for that purpose. The roots are about half a foot asunder. Water is brought over them a second time. For the convenience of irrigation, and to regulate its proportion, the rice fields are subdivided by narrow ridges of clay, into small inclosures. Through a channel, in each ridge, the water is conveyed at will to every subdivision of the field. As the rice approaches to maturity, the water, by evaporation and absorption, disappears entirely; and the crop, when ripe, covers dry ground. The first crop or harvest, in the southern provinces particularly, happens towards the end of May or beginning of June. The instrument for reaping is a small sickle, dentated like a saw, and crooked. Neither carts nor cattle are used to carry the sheaves off from the spot where they were reaped; but they are placed regularly in frames, two of which, suspended at the extremities of a bamboo pole, are carried across the shoulders of a man, to the place intended for disengaging the grain from the stems which had supported it. This operation is performed, not only by a flail, as is customary in Europe, or by cattle treading the corn in the manner of other Orientalists, but sometimes also by striking it against a plank set upon its edge, or beating it against the side of a large tub scolloped for that purpose; the back and sides being much higher than the front, to prevent the grain from being dispersed. After being winnowed, it is carried to the granary.

"To remove the skin or husk of rice, a large strong earthen vessel, or hollow stone, in form somewhat like that which is used elsewhere for filtering water, is fixed firmly in the ground, and the grain, placed in it, is struck with a conical stone fixed to the extremity of a lever, [illegible] indeed imperfectly, the husk, [illegible] by a person treading u[illegible] object is attained [illegible] two flat stones of [illegible] round upo[illegible] not to break the [illegible] formed on a larger [illegible] axis of the wheel carrying [illegible] king upon the [illegible] of levers [illegible] manner [illegible] done by [illegible] twenty [illegible] levers [illegible] from which [illegible] into chaff to serve [illegible] employed [illegible]

"The [illegible] hour [illegible] ground is [illegible] of fresh seeds. [illegible] is that of pulling up [illegible] small heaps, which are [illegible] upon the field. The former processes are afterwards renewed. The second crop is generally ripe late in October or early in November. The grain is treated as before; but the stubble is no longer burnt. It is turned under with the plough, and left to putrefy in the earth. This, with the slime brought upon the ground by inundation, are the only manures usually employed in the culture of rice."

RIDEAU, in fortification, a small elevation of earth, extending itself lengthwise on a plain; serving to cover a camp, or give an advantage to a post.

Rideau is sometimes also used for a trench, the earth of which is thrown up on its side, to serve as a parapet for covering the men.

RIDLEY (Dr Gloster), was of the same family with Dr Nicolas Ridley, Bishop of London, and Martyr to the Reformation. (See Ridley, *Encycl.*) He was born at sea, in 1702, on board the Gloucester East Indiaman; to which circumstance he was indebted for his

his Christian name. He received his education at Winchester school, and thence was elected to a fellowship at New college, Oxford, where he proceeded B. C. L. April 29. 1729. In those two seminaries he cultivated an early acquaintance with the muses, and laid the foundation of those elegant and solid acquirements for which he was afterwards so eminently distinguished as a poet, an historian, and a divine. During a vacancy in 1728, he joined with four friends, viz. Mr Thomas Fletcher (afterwards Bishop of Kildare), Mr (afterwards Dr) Eyre, Mr Morrison, and Mr Jennens, in writing a tragedy called "The Fruitless Redress," each undertaking an act on a plan previously concerted. When they delivered in their several proportions at their meeting in the winter, few readers would have known that the whole was not the production of a single hand. This tragedy, which was offered to Mr Wilks, but never acted, is still in MS. with another called "Jugurtha." Dr Ridley in his youth was much addicted to theatrical performances. Midhurst, in Sussex, was the place where they were exhibited; and the company of gentlemen actors to which he belonged consisted chiefly of his coadjutors in the tragedy already mentioned. He is said to have performed the characters of Marc Antony, Jaffier, Horatio, and Moneses, with distinguished applause; a circumstance that will be readily believed by those who are no [illegible] to his judicious and graceful [illegible]

For [illegible] preferment than [illegible] in Norfolk, and [illegible] where he resided. [illegible] after, the dona[illegible] Between these two places [illegible] (as he expressed it) rolled for [illegible] upon postchaise wheels, [illegible] time for even the proper studies of [illegible] ones of his profession." Yet [illegible] possession of, [illegible] and was honour[illegible] who were not [illegible] for worth.

In [illegible] "Eight Sermons at Lady Moyer's Lectures," which were published in 1742, 8vo. In 1756 he declined an offer of going to Ireland as first chaplain to the Duke of Bedford; in return for which he was to have had the choice of promotion, ther at Christ-church, Canterbury, Westminster, Windsor. His modesty inducing him to leave choice of these to his patron, the consequence was, he obtained none of them. In 1763, he published "Life of Bishop Ridley," in 4to, by subscription, and cleared by it as much as brought him 800l. in the public funds. In the latter part of his life he had the misfortune to lose both his sons, each of them a youth of abilities. The elder, James, was author of "The Tales of the Genii," and some other literary performances. Thomas, the younger, was sent by the East India Company as a writer to Madras, where he was no sooner settled than he died of the small-pox. In 1765, Dr Ridley published his "Review of Philips's Life of Cardinal Pole;" and in 1768, in reward for his labours in this controversy, and in another which "The Confessional" produced, he was presented by Archbishop Secker to a golden prebend in the cathedral church of Salisbury (an option), the only reward he received from the great during a long, useful, and laborious life, devoted to the duties of his function. At length, worn out with infirmities, he departed this life in 1774, leaving a widow and four daughters. His epitaph, which was written by Bishop Lowth with his usual elegance, informs us, that for his merits the university of Oxford conferred upon him the degree of D. D. by diploma, which is the highest literary honour which that learned body has to bestow.

Rienzi.

RIENZI (Nicolas Gabrini de), one of the most extraordinary men of the 14th century, was born at Rome, we know not in what year. His father, Lawrence Gabrini, was a mean vintner, or, as others say, a miller, and his mother a laundress. These persons, however, found the means of giving their son a liberal education; and to a good natural understanding he joined an uncommon assiduity, and made great proficiency in ancient literature. Every thing which he read he compared with similar passages that occurred within his own observation; whence he made reflections, by which he regulated his conduct. To this he added a great knowledge in the laws and customs of nations. He had a vast memory: he retained much of Cicero, Valerius Maximus, Livy, the two Senecas, and Cæsar's Commentaries especially, which he read continually, and often quoted by application to the events of his own times. This fund of learning proved the basis and foundation of his rise. The desire he had to distinguish himself in the knowledge of monumental history, drew him to another sort of science, in which few men at that time exerted themselves. He passed whole days among the inscriptions which are to be found at Rome, and acquired soon the reputation of a great antiquary. Having hence formed within himself the most exalted notions of the justice, liberty, and ancient grandeur of the old Romans, words he was perpetually repeating to the people, he at length persuaded not only himself, but the giddy mob his followers, that he should one day become the restorer of the Roman republic. His advantageous stature, his countenance, and that air of importance which he well knew how to assume, deeply imprinted all that he said in the minds of his audience.

Nor was it only by the populace that he was admired; he also found means to insinuate himself into the favour of those who partook of the administration. Rienzi's talents procured him to be nominated one of the deputies sent by the Romans to Pope Clement VI. who resided at Avignon. The intention of this deputation was to make his Holiness sensible, how prejudicial his absence was, as well to himself as to the interest of Rome. At his first audience, our hero charmed the court of Avignon by his eloquence and the sprightliness of his conversation. Encouraged by success, he one day took the liberty to tell the Pope, that the grandees of Rome were avowed robbers, public thieves, infamous adulterers, and illustrious profligates; who, by their example, authorised the most horrid crimes. To them he attributed the desolation of Rome; of which he drew so lively a picture, that the Holy Father was moved, and exceedingly incensed against the Roman nobility. Cardinal Colonna, in other respects a lover of real merit, could not help considering these reproaches as reflecting upon some of his family; and therefore found means of disgracing Rienzi, so that he

fell into extreme misery, vexation, and sickness, which, joined with indigence, brought him to an hospital. Nevertheless, the same hand that threw him down, raised him up again. The cardinal, who was all compassion, caused him to appear before the Pope, in assurance of his being a good man, and a great partizan for justice and equity. The Pope approved of him more than ever; and, to give him proofs of his esteem and confidence, made him apostolic notary, and sent him back loaded with favours.

Being returned to Rome, he began to execute the functions of his office; and by affability, candour, assiduity, and impartiality, in the administration of justice, he arrived at a superior degree of popularity; which he still improved by continued invectives against the vices of the great, whom he took care to render as odious as possible; till at last, for some ill-timed freedoms of speech, he was not only severely reprimanded, but displaced. From this time it was his constant endeavour to inspire the people with a fondness for their ancient liberties; to which purpose he caused to be hung up in the most public places emblematic pictures, expressive of the former splendour and present decline of Rome. To these he added frequent harangues and predictions upon the same subject. In this manner he proceeded till one party looked on him only as a madman, while others caressed him as their protector. At length he ventured to open himself to such as he believed male contents. At first he took them separately; afterwards, when he thought he had firmly attached a sufficient number to his interest, he assembled them together, and represented to them the deplorable state of the city, over run with debaucheries, and the incapacities of their governors to correct or amend them. As a necessary foundation for the enterprise, he gave them an insight into the immense revenues of the apostolic chamber: He demonstrated, that the Pope could, only at the rate of fourpence, raise a hundred thousand florins by firing, as much by salt, and as much more by the customs and others duties. As for the rest, said he, I would not have you imagine that it is without the Pope's consent I lay hands on the revenues. Alas! how many others in this city plunder the effects of the church contrary to his will!

By this artful lie, he so animated his auditors, that they declared they would make no scruple of securing these treasures for whatever end might be most convenient; and that they were devoted to the will of him their chief. Having obtained so much, to secure his adherents from a revolt, he tendered them a paper, superscribed, "an *oath* to procure the good establishment;" and made them subscribe and swear to it before he dismissed them. By what means he prevailed on the Pope's vicar to give a tacit sanction to his project, is not certainly known; that he did procure that sanction, and that it was looked on as a masterpiece of policy, is generally admitted. "The 20th of May, being Whitsunday, he fixed upon to sanctify in some sort his enterprise; and pretended, that all he acted was by particular inspiration of the Holy Ghost. About nine, he came out of the church bare-headed, accompanied by the Pope's vicar, surrounded by an hundred armed men. A vast crowd followed him with shouts and acclamations." The gentlemen conspirators carried three standards before him, on which were wrought devices, insinuating, that his design was to re-establish liberty, justice, and peace. In this manner he proceeded directly to the Capitol, where he mounted the rostrum; and, with more boldness and energy than ever, expatiated on the miseries to which the Romans were reduced: at the same time telling them, without hesitation, "that the happy hour of their deliverance was at length come, and that he was to be their deliverer, regardless of the dangers he was exposed to for the service of the Holy Father and the people's safety." After which, he ordered the laws of what he called the good establishment to be read: "assured that the Romans would resolve to observe these laws, he engaged in a short time to re-establish them in their ancient grandeur."

The laws of the good establishment promised plenty and security, which were greatly wanted; and the humiliation of the nobility, who were deemed common oppressors. Such laws could not fail of being agreeable to a people who found in them these double advantages; wherefore, "enraptured with the pleasing ideas of a liberty to which they were at present strangers, and the hope of gain, they came most zealously into the fanaticism of Rienzi. They resumed the pretended authority of the Romans; they declared him sovereign [illegible] power of life and [illegible] and repealing [illegible] a word, [illegible] over all the [illegible] Rienzi [illegible] willing to [illegible] tions, the [illegible] vicar (the Bishop [illegible] cond, that the Pope [illegible] which (he told them) [illegible] tain. [illegible] one [illegible] thus [illegible] the other [illegible] would [illegible] graced [illegible] he possessed [illegible] Bishop [illegible] prises. [illegible] an idol, to [illegible] dismissed [illegible] and hope. He seized upon the palace, where he continued after he had turned out the senators; and, the same day, he began to dictate his laws in the Capitol." This election, though not very pleasing to the Pope, was ratified by him; nevertheless, Rienzi meditated the obtaining of a title, exclusive of the papal prerogative. Well versed in the Roman history, he was no stranger to the extent of the tribunitial authority; and as he owed his elevation to the people, he chose to have the title of their magistrate. He asked it, and it was conferred on him and his copartner, with the addition of deliverers of their country. Our adventurer's behaviour in his elevation was at first such as commanded esteem and respect, not only from the Romans, but from all the neighbouring states. But it is difficult for a person of mean birth, elevated at once, by the caprice of fortune, to the most exalted station, to move rightly in a sphere wherein he must breathe an air he has been unaccustomed to. Rienzi ascended by degrees the summit of his fortune.

Rienzi. Riches softened, power dazzled, the pomp of his cavalcades animated, and formed in his mind ideas adequate to those of princes born to empire. Hence luxury invaded his table, and tyranny took possession of his heart. The Pope conceived his designs to be contrary to the interests of the holy see; and the nobles, whose power it had been his constant endeavours to depress, conspired against him: they succeeded; and Rienzi was forced to quit an authority he had possessed little more than six months. It was to a precipitate flight that he was indebted, at this juncture, for his life; and to different disguises for his subsequent preservation.

Having made an ineffectual effort at Rome, and "not knowing where to find a new resource to carry on his designs, he took a most bold step, conformable to that rashness which had so often assisted him in his former exploits. He determined to go to Prague, to Charles king of the Romans, whom the year before he had summoned to his tribunal," and who, he foresaw, would deliver him up to a Pope highly incensed against him. He was accordingly soon after sent to Avignon, and there thrown into a prison, where he continued three years. The divisions and disturbances in Italy, occasioned by the number of petty tyrants that had established themselves [illegible] territories, and even at Rome, [illegible] Innocent VI. who [illegible] sensible that the Romans [illegible] our hero, [illegible] teach him to [illegible] formerly done [illegible] for [illegible] inviolable at[illegible] should be [illegible] instrument to [illegible] other tyrants; and [illegible] his liberty, but also ap[illegible] of [illegible] He met [illegible] newly [illegible] resolu[illegible] his [illegible] inclined [illegible] against him, that he [illegible]

"Such was the [illegible] one of the most renowned [illegible] forming a conspiracy full of extravagance, and executing it in the sight of almost the whole world, with such success that he became sovereign of Rome; after causing plenty, justice, and liberty, to flourish among the Romans; after protecting potentates, and terrifying sovereign princes; after being arbiter of crowned heads; after reestablishing the ancient majesty and power of the Roman republic, and filling all Europe with his fame during the seven months of his first reign; after having compelled his masters themselves to confirm him in the authority he had usurped against their interests—fell at length at the end of his second, which lasted not four months, a sacrifice to the nobility, whose ruin he had vowed, and to those vast projects which his death prevented him from putting into execution*."

If the reader perceive any thing similar at present to the rise of this wonderful man to sovereign authority, he may perhaps console himself with the hope that the modern consul will in all probability fall like the modern tribune. Both rose by displays of the most daring courage; the associates of both were priests, who in the actual exercise of government were cyphers; both promised liberty and plenty to the people whom they ruled with absolute sway; and both have trampled upon the order of nobility.

* Biog. Dict. new edit.

Ring || Rodney.

RING, in astronomy and navigation, an instrument used for taking the sun's altitude, &c. It is usually of brass, about nine inches diameter, suspended by a little swivel, at the distance of 45° from the point of which is a perforation, which is the centre of a quadrant of 90° divided in the inner concave surface. To use it, let it be held up by the swivel, and turned round to the sun, till his rays, falling through the hole, make a spot among the degrees, which marks the altitude required. This instrument is preferred before the astrolabe, because the divisions are here larger than on that instrument.

ROBERVALLIAN LINES, a name given to certain lines used for the transformation of figures; thus called from their inventor Roberval, an eminent French mathematician, who died in 1675, aged 76 years. These lines bound spaces that are infinitely extended in length, which are nevertheless equal to other spaces that are terminated on all sides.

The Abbot Gallois, in the Memoirs of the Royal Academy, anno 1693, observes, that the method of transforming figures, explained at the latter end of Roberval's Treatise of Indivisibles, was the same with that afterwards published by James Gregory, in his *Geometria Universalis*, and also by Barrow in his *Lectiones Geometricæ*; and that, by a letter of Torricelli, it appears, that Roberval was the inventor of this manner of transforming figures, by means of certain lines, which Torricelli therefore called *Robervallian lines*. He adds, that it is highly probable that J. Gregory first learned the method in the journey he made to Padua in 1668, the method itself having been known in Italy from the year 1646, though the book was not published till the year 1692.

This account has been, we think, completely refuted by David Gregory in his vindication of his uncle, published in the Philosophical Transactions of 1694. The Abbot, however, rejoined in the Memoirs of the French Academy of 1703; and it is but fair to observe, that Dr Hutton, speaking of the controversy, expresses himself as if he thought it undecided.

RODNEY (Lord). In our short sketch of the life of that gallant officer (*Encycl.*), we mentioned with regret our not having heard of any monument being erected to his honour in his native country. We have since learned that there is a pillar upon the Brythen in Shropshire, which was erected to his memory long before the publication of our article.

Having this great man again under our notice, we insert with pleasure the following extract of a letter, which we received from an obliging correspondent soon after the publication of the volume which contains our biographical sketch of the Admiral: "Whatever were Rodney's merits as a naval commander (says our correspondent), there is a more brilliant part of his character which you have entirely neglected. Prior to his success against the Spanish Admiral Don Langara, the English who had the misfortune to become prisoners of war to the Spaniards, were treated with the greatest inhumanity, and it required more than a common

ftrength of conftitution to exift for any length of time in a Spanifh prifon. When the Spanifh admiral fell into the hands of Rodney, he, his officers and feamen, expected to meet with the fame treatment they had always inflicted, and which they would have inflicted on Rodney, his officers, and feamen, had the Spaniards been the victors; but, to their furprife, they found in Admiral Rodney (and, of courfe, in all that were under his command) a man who fympathifed in their misfortune, who miniftered to their neceffities, and, by a humane and polite behaviour to his prifoners, made an impreffion on the minds of the Spaniards, which could not but have its effect in mitigating the fufferings of the Englifh in Spanifh prifons: but he did not ftop here; he took an opportunity, when their minds were expanded by gratitude (and in a ftate to receive the full force of fuch a reprefentation), to reprefent to them the miferable condition of his countrymen who were prifoners in Spain, and obtained a promife (which, I believe, was punctually performed), that Englifhmen, when prifoners in Spain, fhould be made as comfortable as their fituation would admit of. This was a piece of fervice to his country which furely merits to be recorded, and which will exalt him as much in the opinion of good men as the moft brilliant difplay of *courage*, which is a quality as frequently difcovered in the favage as in the cultivated mind."

ROEBUCK (John, M D.), was born at Sheffield in Yorkfhire in the year 1718. His father was a confiderable manufacturer and exporter of Sheffield goods, who by his abilities and induftry had acquired a competent fortune. John, his eldeft fon, the fubject of this memoir, was intended by his father for carrying on his own lucrative bufinefs at Sheffield; but was, from his early youth, irrefiftibly attached to other purfuits, more calculated to gratify his ambition, and give fuller play to his powers. Notwithftanding this difappointment in his favourite object, his father had liberality enough to encourage his rifing genius, and to give him all the advantages of a regular education.

After he had gone through the ufual courfe of the grammar fchool at Sheffield, both his father and mother being ftrict diffenters, they placed their fon for fome years under the tuition of the late Dr Doddridge, who was at that time mafter of an academy at Northampton, and had juftly acquired high reputation among the diffenters, both as a divine and as an inftructor of youth. Under the Doctor's care Mr Roebuck made great proficiency, and laid the foundation of that claffical tafte and knowledge for which he was afterwards eminently diftinguifhed. It would appear that Dr Doddridge had been much pleafed with the ardour and enthufiafm, in the purfuit of knowledge, difcovered by his pupil; for Mr Roebuck, in an after period of his life, ufed frequently to mention the fubjects of converfation and inquiries of various kinds, in which the Doctor had engaged him. It was during his refidence at this academy that he contracted an intimate acquaintance with his fellow-ftudents, Mr Jeremiah Dyfon, afterwards much known in the political world, and Mr Mark Akenfide, afterwards Dr Akenfide, which terminated only with their lives.

From the academy at Northampton he was fent to the univerfity of Edinburgh, where he applied to the ftudy of medicine, and particularly to that of chemiftry, which about that time began to attract fome attention in Scotland. While he refided there, he diftinguifhed himfelf much among his fellow-ftudents in their literary focieties and converfations, by great logical and metaphyfical acutenefs, and by great ingenuity and refource in argumentation. The late fagacious Dr Porterfield, to whom he had been introduced, obferved and encouraged his rifing genius, and was greatly inftrumental in promoting his improvement. There, too, he formed an intimate acquaintance with Mr Hume, Mr Robertfon, afterwards Dr Robertfon, Mr Pringle, afterwards Lord Alemoor, and feveral other perfons of literary eminence; a circumftance which produced in his mind a partiality ever afterwards in favour of Scotland, and contributed not a little to his making choice of it for the chief field of his future exertions and induftry.

After Mr Roebuck had gone through a regular courfe of medical education at Edinburgh, being now determined to follow the practice of phyfic, he next fpent fome time at the univerfity of Leyden, then in high reputation as the firft fchool of medicine in Europe. There, after the ufual refidence and courfe of trials, he obtained a degree in medicine; and his diploma, dated 21ft February 1743, has affixed to it the refpectable names of Mufchenbroek, Ofterdyk, Van Royen, Albinus, Gaubius, &c. He left Leyden, after having vifited fome part of the north of Germany, about the end of the year [illegible].

Soon after his return from the continent, fome circumftances induced Dr Roebuck to fettle as a phyfician at Birmingham. Before that time Birmingham had begun to make a rapid progrefs in its manufactures, and population; and by the death of a noted phyfician, an opening was prefented to him which afforded an immediate profpect of encouragement in that line. His education, talents, and interefting manners were well calculated to promote his fuccefs as a phyfician. He accordingly met there, at a period more early than he expected, with great encouragement; and was foon diftinguifhed, in that town and the country adjacent, for his fkill, integrity, and humane compaffion, in the difcharge of the duties of his profeffion.

It appeared, however, foon after his refidence was fixed at Birmingham, that his ftudies and induftry were turned to various objects befides thofe of his profeffion. Strongly attached to the rifing fcience of chemiftry, he conceived high views of extending its ufefulnefs, and of rendering it fubfervient to the improvement of arts and manufactures. With this view, he fitted up a fmall laboratory in his own houfe, in which he fpent every moment of his time which he could fpare from the duties of his profeffion. There, in the true fpirit of his great mafter Lord Bacon, of whofe philofophy he was an ardent admirer, he carried on various chemical proceffes of great importance, and laid the foundation of his future projects on well-tried and well digefted experiments.

The firft efforts of his genius and induftry, thus directed, led him to the difcovery of certain improved methods of refining gold and filver, and particularly to an ingenious method of collecting the fmaller particles of thefe precious metals, which had been formerly loft in the practical operations of many of the manufacturers. By other chemical proceffes, carried on about the fame time in his little laboratory, he difcovered alfo improved methods of making fublimate, hartfhorn, and

fundry

Roebuck sundry other articles of equal importance. After having received full satisfaction from the experiments upon which such discoveries and improvement were founded, he next digested a plan for rendering them beneficial to himself, and useful to the public. A great part of his time being still employed in the duties of his profession, he found it necessary to connect himself with some person in whom he could repose confidence, and who might be, in other respects, qualified to give him support and assistance in carrying on his intended establishments. With this view, he chose as his associate Mr Samuel Garbet of Birmingham; a gentleman well qualified, by his abilities, activity, and enterprising spirit, for bearing his part in their future undertakings. Their first project was the establishment of an extensive laboratory at Birmingham, for the purposes above mentioned; which, conducted by Dr Roebuck's chemical knowledge, and Mr Garbet's able and judicious management, was productive of many advantages to the manufacturers of that place, and of such emolument to themselves, as contributed greatly to the boldness of their future projects. That laboratory has, ever since that time, continued at Birmingham, and is still conducted by Mr Garbet. Dr Roebuck, long before his death, had given up his interest in it.

About this time, in 1747, the Doctor married Miss Ann Roe of [illegible] spirit, whose [illegible] for enjoying [illegible] their early life, [illegible] anxieties [illegible] but did [illegible] of their lives.

[illegible] perseverance in his chemical [illegible] with the success that attended them, [illegible] step, to other researches of great public [illegible] benefit.

[illegible] of the vitriolic [illegible] acid in [illegible] application to some of [illegible] for that [illegible] various [illegible] had obtained a patent [illegible] though the substances from which it might be obtained, as well as certain methods of obtaining it, had been known to others, and particularly pointed out by Lemery the Elder, and by Glauber, yet Dr Ward was the first, it is believed, who established a profitable manufacture upon the discovery. Much, however, was wanting to render the acid of universal use in chemistry, and of extensive utility in the arts, where great quantities of it were required. The price of it was high, arising from the great expence of the glass vessels, which were made use of by Dr Ward in procuring it, and the frequent accidents to which they were liable in the process.

Dr Roebuck had been for some time engaged in making experiments with a view to reduce the price, and at length discovered a method of preparing it, by substituting, in place of the glass vessels formerly used, lead ones of a great size; which substitution, together with sundry other improvements in different parts of the process, completely effected his end.

After the necessary preparations had been made, Messrs Roebuck and Garbet established a manufacture of the oil of vitriol at Prestonpans, in Scotland, in the year 1749. This establishment not a little alarmed Dr Ward, who attempted to defeat their plan, by taking out a patent for Scotland, in addition to the one he had formerly obtained. In this attempt he failed. Dr Roebuck's discovery was found not to come within the specification of Dr Ward's patent.

The Prestonpans company, convinced that patents are of little avail in preserving the property of new inventions or discoveries, in conducting their vitriol works resolved to have recourse to the more effectual methods of concealment and secrecy. By that method they were enabled to preserve the advantages of their ingenuity and industry for a long period of years, and not only served the public at a much cheaper rate than had ever been done formerly, but, it is believed, they realized, in that manufacture, a greater annual profit from a smaller capital than had been done in any similar undertaking. The vitriol work is still carried on at Prestonpans; but long before Dr Roebuck's death, he was obliged to withdraw his capital from it.

About this time Dr Roebuck was urged, by some of his friends, to leave Birmingham, and to settle as a physician in London, where his abilities might have had a more extensive field of exertion. He had been early honoured with the acquaintance of the late Marquis of Rockingham, who, as a lover of arts, had frequently engaged him in chemical experiments at Rockingham-house. It was there, also, he became acquainted with the late Sir George Saville, and with several other persons of rank and influence. His old friend and schoolfellow Mr Dyson, too, by this time, had acquired considerable name and influence, and pressed him much to take that step. Under such patronage, and with the energy of such talents as Dr Roebuck possessed, there could be little doubt of his soon arriving at an eminent rank as a physician in London. But the chemical concerns, with which he was at that time deeply occupied, holding out to him a prospect of a richer harvest, determined him to give up the practice of medicine altogether, and to fix his residence for the greatest part of the year in Scotland.

The success of the establishment at Prestonpans, which had far exceeded their expectation, enabled the Doctor and his partner Mr Garbet to plan and execute other works of still greater benefit and public utility. In the prosecution of his chemical studies and experiments, Dr Roebuck had been led to bestow great attention on the processes of smelting iron-stone, and had made some discoveries, by which that operation might be greatly facilitated, particularly by using pit-coal in place of charcoal. Mr William Caddell of Cockenzie, in the neighbourhood of Prestonpans, a gentleman earnestly intent upon promoting manufactures in Scotland, had, for several years, laboured, without much success, in establishing a manufacture of iron; a circumstance which may have probably contributed to turn Dr Roebuck's attention more particularly to that subject. As the capital which he and his partner Mr Garbet could appropriate for carrying on the iron manufacture was not equal to such an undertaking, and chiefly depended upon the profits of their other works, their first intention was to attempt a small establishment of that kind in the vicinity of their vitriol works at Prestonpans. But the flattering prospects of success, arising from a course of experiments which Dr Roebuck had lately made, encouraged them to extend their plan,

Roebuck.

plan, and to project a very extensive manufactory of iron. A sufficient capital was soon procured, through the confidence which many of their friends reposed in their abilities and integrity. In fact, the establishment which they made, or rather the capital which gave it existence, was the united capital of a band of relations and friends, who trusted to Dr Roebuck and Mr Garbet the management of a great part of their fortune. When all previous matters had been concerted respecting their intended establishment, the chief exertions of chemical and mechanical skill, necessary in the execution, were expected from Dr Roebuck. It fell to his share also to fix upon the best and most favourite situation for erecting their intended works. With that view Dr Roebuck examined many different places in Scotland, particularly those on both sides of the Frith of Forth; and after a careful and minute comparison of their advantages and disadvantages, he at length made choice of a spot on the banks of the river *Carron* as the most advantageous situation for the establishment of the iron manufacture. There he found they could easily command abundance of water for the necessary machinery; and in the neighbourhood of it, as well as everywhere both along the north and south-coasts of the Frith, were to be found inexhaustible quarries of ironstone, limestone, and coal. From Carron, also, they could easily transport their manufactures to different countries by sea. The communication with Glasgow at that time by land carriage, which opened up to them a ready way to the American market, was short and easy.

Many other things, that need not be here enumerated, fell to Dr Roebuck's share in preparing and providing for the introduction of this new manufacture into Scotland, particularly with respect to the planning and erection of the furnaces and machinery. To insure success in that department, nothing was omitted which ability, industry, and experience could suggest. With this view, he called to his assistance Mr Smeaton, then by far the first engineer in England. It was from him he received plans and drawings of the water-wheels and blowing apparatus, which, notwithstanding all the mechanical improvements which have been made since, remain unrivalled in any of the other iron-works erected in Britain. This was the first introduction of Mr Smeaton into Scotland, and was the occasion of various other displays of the skill and experience of that celebrated engineer in that part of the island. With the same view, and to the same effect, in a future period of his operations, he employed Mr James Watt, then of Glasgow, and had the merit of rendering that inventive genius, in the mechanical arts, better known both in this country and in England.

The necessary preparations for the establishment of the iron-works at Carron were finished in the end of the year 1759; and on the 1st January 1760 the first furnace was blown; and in a short time afterwards a second was erected.

No period of Dr Roebuck's life required from him more vigorous and laborious exertions than that of the establishment of the Carron works, and the first trials of the furnaces and machinery. His family and friends remember well the ardour and interest which he discovered; the incessant labour and watchfulness which he exerted on that occasion. Every thing was untried, the furnaces, the machinery, the materials, the workmen; the novelty of the undertaking in that country, its extent and difficulty, and the great stake at issue, were circumstances that must have occasioned much serious thought and anxiety to the partner, upon the credit of whose knowledge and experience the work had been undertaken. But the Doctor had great powers and great resources; and the first trial gave sufficient indications of future success.

For some time after the establishment of the Carron works, Dr Roebuck continued to give his attention and assistance in the general management and superintendance of them, and with him all measures of future operations were concerted. During this period, some alterations of great importance were suggested by him, and carried into effect. By carefully observing the progress of smelting in the furnaces, at first worked by bellows, besides their being subject to various accidents, the Doctor discovered the necessity of rendering the blast both stronger and more equable; and proposing, as a problem to Mr Smeaton, the best method of effecting that end, that celebrated engineer soon gave the plan of a blast by three or four cylinders, which was afterwards tried, and succeeded even beyond expectation.

When the business at Carron sunk by degrees into a matter of ordinary detail, and afforded less scope for the Doctor's peculiar talents, he was unfortunately tempted to engage in a new and different undertaking, from the failure of which he suffered a reverse of fortune, was deprived of the advantages resulting from his other works, and during the remainder of his life became subjected to much anxiety and disappointment.

The establishment of the Carron works, and the interest Dr Roebuck had in their success, had naturally turned his attention to the state of coal in the neighbourhood of that place, and to the means of procuring the extraordinary supplies of it which the iron works might in future require. With the view therefore of increasing the quantity of coal wrought in that neighbourhood, by an adventure which he thought would also turn out to his own emolument, he was induced to become lessee of the Duke of Hamilton's extensive coal and salt works at Borrowstounness. The coal there was represented to exist in great abundance, and understood to be of superior quality; and as Dr Roebuck had made himself acquainted with the most improved methods of working coal in England, and then not practised in Scotland, he had little doubt of this adventure turning out beneficial and highly lucrative. In this, however, he was cruelly disappointed. The opening of the principal stratum of coal required much longer time, and much greater expence, than had been calculated; and, after it was opened, the perpetual succession of difficulties and obstacles which occurred in the working and raising of the coal, was such as has been seldom experienced in any work of that kind. The result was, that after many years of labour and industry, there were sunk in the coal and salt works at Borrowstounness, not only his own, and the considerable fortune brought him by his wife, but the regular profits of his more successful works; and along therewith, what distressed him above every thing, great sums of money borrowed from his relations and friends, which he was never able to repay; not to mention that, from the same cause, he was, during the last twenty years of his

Roebuck. his life, subjected to a constant succession of hopes and disappointments, to a course of labour and drudgery ill suited to his taste and turn of mind, to the irksome and teasing business of managing and studying the humours of working colliers. But all these difficulties his unconquerable and persevering spirit would have overcome, if the never-ceasing demands of his coal-works, after having exhausted the profits, had not also compelled him to withdraw his capital from all his different works in succession; from the refining work at Birmingham, the vitriol work at Prestonpans, the ironworks at Carron, as well as to part with his interest in the project of improving the steam-engine, in which he had become a partner with Mr Watt, the original inventor, and from which he had reason to hope for future emolument.

It would be painful to mention the unhappy consequences of this ruinous adventure to his family and to himself. It cut off for ever the flattering prospect which they had of an independent fortune, suited to their education and rank in life. It made many cruel encroachments upon the time and occupations of a man whose mind was equally fitted to enjoy the high attainments of science, and the elegant amusements of taste. As the price of so many sacrifices, he was only enabled to draw from his colliery, and that by the indulgence of his creditors, a moderate annual maintenance for himself and family during his life. At his death, his widow was left without any provision whatever for her immediate or future support, and without the smallest advantage from the extraordinary exertions and meritorious industry of her husband.

Dr Roebuck had, some years before his death, been attacked by a complaint that required a dangerous chirurgical operation. That operation he supported with his usual spirit and resolution. In a short time he was restored to a considerable share of his former health and activity; but the effects of it never entirely left him, and [illegible] gradually impaired his constitution. [illegible] continued, till within a few [illegible] of his death, to visit his works, and to give directions to his clerks and overseers. He was confined to his bed only a few days, and died on the 17th July 1794, retaining to the last all his faculties, his spirit and good humour, as well as the great interest which he took, as a man of science and reflection, in the uncommon events which the present age has exhibited.

From a man so deeply and so constantly engaged in the detail of active business, many literary compositions were not to be expected. Dr Roebuck left behind him many *works*, but few *writings*. The great object which he kept invariably in view was to promote arts and manufactures, rather than to establish theories or hypotheses. The few essays which he left, enable us to judge of what might have been expected from his talents, knowledge, and boldness of invention, had not the active undertakings in which, from an early period of life, he was engaged, and the fatiguing details of business, occupied the time for study and investigation. A comparison of the heat of London and Edinburgh, read in the Royal Society of London June 29. 1775; experiments on ignited bodies, read there 16th Feb. 1776; observations on the ripening and filling of corn, read in the Royal Society of Edinburgh 5th June 1784—are all the writings of his, two political pamphlets excepted, which have been published. The publication of the essay on ignited bodies was occasioned by a report of some experiments made by the Comte de Buffon, from which the Comte had inferred, that *matter* is heavier when hot than when cold. Dr Roebuck's experiments, made with great accuracy before a committee of the Royal Society at London, seem to refute that notion.

It is the works and establishments projected and executed by Dr Roebuck, with the immediate and more remote effects of them upon the industry, arts, and manufactures of Scotland, which urge a just claim to the respect and gratitude of his country. This tribute is more due from the discerning part of mankind, as this species of merit is apt to be overlooked by the busy or the superficial, and to fail in obtaining its due reward. The circumstances of Dr Roebuck were, in this respect, peculiarly hard: for though, most certainly, the projector and author of new establishments highly useful to his country, and every day becoming more so, he was, by a train of unfortunate events, obliged to break off his connection with them, at an unseasonable time, when much was yet wanting to their complete success; and thus he left others in the possession, not only of the lucrative advantages now derived from them, but even in some measure of the general merit of the undertaking, to a considerable part of which he had the most undoubted claim.

The establishment of the laboratory at Birmingham in the year 1747, the first public exhibition of Dr Roebuck's chemical talents, was, at that particular period, and in the state of the arts and manufactures at that time, highly beneficial, and subservient to their future progress: and the continuance and success of it, in that place, is a proof of the advantages which many of the manufacturers receive from it. Much had already been done, and many improvements made in arts and manufactures, chiefly by the suggestions of that ingenuity and experience which, in the detail of business, might be expected from the practical artist. Dr Roebuck was qualified to proceed a step farther; to direct experience by principles, and to regulate the mechanical operation of the artist by the lights of science. The effects of that establishment extended, in a particular manner, to all that variety of manufactures in which gold and silver were required, to the preparing of materials, the simplifying of the first steps, to the saving of expence and labour, and to the turning to some account what had been formerly lost to the manufacturer. It is well known that, while Dr Roebuck resided at Birmingham, such was the opinion formed of his chemical knowledge and experience by the principal manufacturers, that they usually consulted him on any new trial or effort to improve their several manufactures; and when he left that place, they sincerely regretted the loss of that easy and unreserved communication they had with him on the subjects of their several departments.

On account of similar circumstances, the benefit to the public, from the establishment of the vitriol works at Prestonpans, in the extension and improvement of many of the arts, cannot now be exactly ascertained. The vitriolic acid is one of the most active agents in chemistry, and every discovery which renders it cheap and accessible to the chemist must be greatly subservient

to

to the progress of that science. By the establishment at Prestonpans, the price of that valuable acid was reduced from sixteen to four pence *per* pound. It is to Dr Roebuck, therefore, that chemists are indebted for being in possession of a cheap acid, to which they can have recourse in so many processes.

But Dr Roebuck's object in the prosecution of that scheme, was not so much to facilitate the chemist's labour, as to render that acid, in a much higher degree than it had formerly been, subservient to many of the practical arts. By rendering the vitriolic acid cheap, great use came to be made of it in preparing the muriatic acid, and Glauber's salts from common salts. Its use has been farther extended to many metallic processes; and it has lately been employed in separating silver from the clippings of plated copper, the use of which is very extensive.

The project and establishment, however, of the iron-works at Carron, the most extensive establishment of that kind hitherto in Britain, must be considered as Dr Roebuck's principal work. The great and increasing demand for iron in the progressive state of arts, manufactures, and commerce in Britain, and the great sums of money sent every year to the north of Europe for that article, turned the attention of chemists and artists to the means of promoting the manufacture of iron, with the view of reducing the importation of it. No person has a better founded claim to merit, in this particular, than Dr Roebuck. The smelting of iron by pitcoal, it is indeed believed, had been attempted in Britain in the beginning of the last century. In the reign of James I. several patents seem to have been granted for making hammered iron by pitcoal, particularly to the Hon. Dud Dudley and Simon Starlevant. It does not appear, however, that any progress had been made in the manufacture in consequence of these patents. In later times trials have been made by so many different persons, and in so many different places in England, nearly about the same time, that it may be difficult to say where and by whom the first attempt was made, particularly as the discoverers of such processes wished to conceal the knowledge they had gained as long as they could. But Dr Roebuck was certainly among the first who, by means of pitcoal, attempted to refine crude or pig iron, and to make bar iron of it, instead of doing it by charcoal, according to the former practice: And he was, without all question, the person who introduced that method into Scotland, and first established an extensive manufacture of it. It is not meant to ascribe to him the sole merit of the establishment at Carron. No man was ever more ready than he was to do justice to the abilities and spirit of his friends and partners Messrs Garbet, Caddell, &c. who first embarked with him in that great undertaking. But still it may be said with truth, that the original project of the iron-works at Carron, the chemical knowledge and experience on which they were founded, the complicated calculations which were previously required, the choice of the situation, the general conduct and direction of the buildings and machinery, the suggestion of many occasional improvements, together with the removal of many unforeseen obstacles and difficulties, which occurred in the infant state of that establishment, were, in a great measure, the work and labour of Dr Roebuck. Nor can it, with the least shadow of justice, detract from his merit, that a larger capital, and greater expence than was at first calculated, have been found necessary to bring the works at Carron to their present state of perfection; or, that great alterations and improvements have taken place, during the course of forty years, in a great and progressive establishment. In all works of that kind, the expence exceeds the calculation. The undertakers, even of the latest iron works which have been erected, notwithstanding all the advantages obtained from recent experience, will be ready to acknowledge, that, in these respects, there is little room to blame the original projector of the first establishment of that kind in Scotland. But the best, and most infallible proof of Dr Roebuck's merit, and of the sound principles on which these works were established, is the present prosperous state of that establishment, the great perfection of many branches of their manufactures, and particularly the many extensive and flourishing iron-works which have since been erected upon the model of Carron in different parts of Scotland, at Cleugh, Clyde, Muirkirk, and Devon. It cannot be denied that all these works have sprung from the establishment at Carron, and are ultimately founded upon the knowledge and experience which have been obtained from them; for some of the partners, or overseers of these new works, and many of the workmen, have been, at one time or another, connected with that of Carron. Hence, then, it is owing to the projector and promoter of the establishment at Carron, that Scotland is, at this moment, benefited to the amount of many hundred thousand pounds, in working up the raw materials of that manufacture found in the country itself, and which, previous to that establishment, was of no value whatever. Such are the *present*, but scarcely any idea can be formed of the *future*, advantages to this country, which may be derived from the extension of the iron manufacture. About 60,000 tons of iron have been annually imported into Great Britain for more than twenty years past; and though there has been for some time about 20,000 tons of bar iron made in Britain by pitcoal, yet the foreign imported iron has suffered little or no diminution in quantity. The great consumption of iron, no doubt, is owing to the various improvements of late years, and the general extension throughout all Europe of commerce and the arts. The manufacture of iron must therefore continue to increase; and Scotland, abounding everywhere in ironstone, pitcoal, and in command of water for machinery, has the prospect of obtaining the largest share of it.

To the establishment of the Carron works, and to the consequences of that establishment, may be ascribed also the existence of other public works in Scotland of great importance and utility. The opening of a communication by water betwixt the Forth and the Clyde had long been projected, and frequently the subject of conversation in Scotland, but nothing in fact had been attempted. The establishment of the iron-works at Carron soon called forth sufficient interest and enterprise to bring about the execution of this grand design. Some of the partners of the Carron company, foreseeing the advantages they would derive from such a communication, proposed, at their own expence, to execute a small canal; and, after taking the preparatory steps, actually applied to Parliament to obtain authority for that purpose. But the project of the small canal not meeting

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meeting with the approbation of some noblemen and gentlemen in that part of Scotland, they opposed the bill, and obliged themselves to execute a greater canal, which has now been many years finished, and is found to be of the greatest advantage to the trade and commerce of Scotland. The merit of this undertaking is not meant to be ascribed to Dr Roebuck, excepting in so far as it necessarily arose from the establishment of the Carron company, of which he was the original projector; and it may reasonably be doubted whether, without that establishment, it would have yet taken place. Several other canals have, since that time, been executed in different parts of Scotland, and other very important ones are at present projected.

The different establishments which Dr Roebuck made at Borrowstounness in carrying on the coal and salt works there, though ultimately of no advantage to himself, were attended, during the course of thirty years, with the most beneficial effects upon the trade, population, and industry of that part of Scotland. They were the means also of adding very considerably to the public revenue. Previous to the time these works fell under Dr Roebuck's management, they produced no advantage either to the proprietor, to the adventurers, or to the public. But by his mode of conducting them upon a more extensive plan, by opening up new seams of coal, and of better quality, he was enabled to export a very considerable quantity, to increase the quantity of salt, and of course the revenue arising from these articles. In these works, and in the management of a large farm, Dr Roebuck gave employment to near a thousand persons at Borrowstounness and in the neighbourhood.

[illegible] by the different establishments which he projected and executed, but by many other things [illegible] connected with them, that Dr Roebuck's labours were beneficial to Scotland. Along with them he [illegible] a [illegible] enterprise and industry, [illegible] in Scotland, [illegible] labour, and gave birth to many other useful projects. He brought from England, then much farther advanced in arts and industry, many ingenious and industrious workmen, at great expence, who, by their instructions and example, communicated and diffused skill and knowledge to others. At all times Dr Roebuck held out liberal encouragement to rising genius and industrious merit; and spared no expence in making trials of improvements and discoveries which were connected with the different projects and works which he was carrying on.

Such was the active and useful life of Dr Roebuck; a man of no common cast, who united, in a very high degree, a great number of solid and brilliant talents, which, even separately, fall to the lot of but few individuals. Distinguished by an ardent and inventive mind, delighting in pursuit and investigation, always aspiring at something beyond the present state of science and art, and eagerly pressing forward to something better or more perfect, he thus united energies the most powerful with the most unwearied and persevering industry. To that peculiarity of imagination, so fitted for scientific pursuit, which readily combines and unites, which steadily preserves its combinations before the eye of the mind, and quickly discovers relations, results, and consequences, was added in his character, great promptitude and firmness in decision. Strongly and early impressed with the great importance of applying chemical and physical knowledge to the useful arts, to the melioration of civil life, he never lost sight of that favourite view; and discovered great boldness and resource in the means and expedients which he adopted to promote it. He was certainly master of the best philosophy of chemistry known in the earlier parts of his life; and though in every stage of that science he marked and understood the progress of the discoveries, yet his numerous avocations did not permit him to follow them out by experimental processes of his own. Upon that, and indeed almost upon every subject, his mind readily grasped the most useful and substantial points, and enabled him to throw out such hints and hypotheses as marked him the man of genius.

During the course of a regular education, both at Edinburgh and at Leyden, Dr Roebuck studied the classic authors with great attention, particularly the historical and political parts of their works. Upon these subjects he had read much, selected with judgment, and was well acquainted with the facts and philosophy of ancient governments. This taste he carried with him, and improved in every period of his life, and in every situation. It abundantly rewarded him for the earnestness and diligence with which it had been acquired. It became his favourite resource, and indeed one of the chief enjoyments of his life. Possessing the happy talent of turning his mind from serious and fatiguing, to elegant and recreating pursuits, it was no uncommon thing with him to return from the laboratory or the coalpit, and draw relaxation or relief from some one or other of the various stores of classical learning.

No man was better acquainted with the history of his country than Dr Roebuck, or more admired and revered the constitution of its government. By temper and education he was a Whig, and at all times entered with great warmth into the political disputes and controversies which agitated parties in the different periods of his life. If the natural warmth of his temper, and his enthusiasm on these subjects, led him, on some occasions, beyond the bounds of candid argumentation, his quick sense of decorum, and his perfect habits of good manners, produced an immediate atonement, and restored the rights of elegant and polished conversation.

The general acquaintance which Dr Roebuck had acquired with natural and experimental philosophy, together with his classical and political knowledge, rendered him an agreeable companion to the learned almost of every department, and procured him the attachment and friendship of many of the first literary characters in Britain. With his friend Dr Black he lived till his death in close habits of intimacy; and he often acknowledged, with much frankness, the advantages which he derived, in his various pursuits, from a free and unreserved communication with that eminent chemist.

The amiable dispositions of sensibility, humanity, and generosity, which strongly marked his character, in the general intercourse of society, were peculiarly preserved and exercised in the bosom of his family, and in the circle of his friends. In the various relations of husband, father, friend, or master, and in the discharge of the respective duties arising from them, it would not be easy to do justice to his character, or to determine in which

Roemer. of them he moſt excelled; nor muſt it be forgot, for it reflected much honour on his benevolent heart, that his workmen not only found him at all times a kind and indulgent maſter, but many of them, when their circumſtances required it, a ſkilful and compaſſionate phyſician, who cheerfully viſited the humbleſt receſſes of poverty, and who attached them to his ſervice by multiplied acts of generoſity and kindneſs.

ROEMER (Olaus), a noted Daniſh aſtronomer and mathematician, was born at Arhuſen in Jutland, 1644; and at 18 years of age was ſent to the univerſity of Copenhagen. He applied aſſiduouſly to the ſtudy of the mathematics and aſtronomy, and became ſo expert in thoſe ſciences, that when Picard was ſent by Louis the XIV. in 1671, to make obſervations in the north, he was greatly ſurpriſed and pleaſed with him. He engaged him to return with him to France, and had him preſented to the king, who honoured him with the dauphin as a pupil in mathematics, and ſettled a penſion upon him. He was joined with Picard and Caſſini, in making aſtronomical obſervations; and in 1672 he was admitted a member of the Academy of Sciences.

During the ten years he reſided at Paris, he gained great reputation by his diſcoveries; yet it is ſaid he complained afterwards, that his coadjutors ran away with the honour of many things which belonged to him. Here it was that Roemer, firſt of any one, found out the velocity with which light moves, by means of the eclipſes of Jupiter's ſatellites. He had obſerved for many years, that when Jupiter was at his greateſt diſtance from the earth where he could be obſerved, the emerſions of his firſt ſatellite happened conſtantly 15 or 16 minutes later than the calculation gave them. Hence he concluded, that the light reflected by Jupiter took up this time in running over the exceſs of diſtance; and conſequently that it took up 16 or 18 minutes in running over the diameter of the earth's orbit, and 8 or 9 in coming from the ſun to us, provided its velocity was nearly uniform. This diſcovery had at firſt many oppoſers; but it was afterwards confirmed by Dr Bradley in the moſt ingenious and beautiful manner.

In 1681 Roemer was recalled to his native country by Chriſtian the Vth King of Denmark, who made him profeſſor of aſtronomy at Copenhagen. The king employed him alſo in reforming the coin and the architecture, in regulating the weights and meaſures, and in meaſuring and laying out the high roads throughout the kingdom; offices which he diſcharged with the greateſt credit and ſatisfaction. In conſequence he was honoured by the king with the appointment of chancellor of the exchequer and other dignities. Finally, he became counſellor of ſtate, and burgomaſter of Copenhagen, under Frederic the IV. the ſucceſſor of Chriſtian. Roemer was preparing to publiſh the reſult of his obſervations, when he died the 19th of September 1710, at 66 years of age: but this loſs was ſupplied by Horrebow, his diſciple, then profeſſor of aſtronomy at Copenhagen, who publiſhed, in 4to, 1753, various obſervations of Roemer, with his method of obſerving, under the title of *Baſis Aſtronomiæ*.—He had alſo printed various aſtronomical obſervations and pieces, in ſeveral volumes of the Memoirs of the Royal Academy of Sciences at Paris, of the inſtitution of 1666, particularly vol. 1. and 10. of that collection.

ROLLOCK (Robert), the firſt principal of the college of Edinburgh, was the ſon of David Rollock of *Poo houſe*, or, as it is now written, *Powis*, in the neighbourhood of Stirling. He was born in 1555; and learned the rudiments of the Latin tongue under one Mr Thomas Buchanan, who kept, ſays Archbiſhop Spottiſwood, a famous ſchool at that time, and was, according to Dr Mackenzie, one of the moſt eminent grammarians in Scotland. Where Mr Buchanan kept his ſchool, neither of theſe authors has informed us.

From ſchool Mr Rollock was ſent, we know not in what year, to the univerſity of St Andrews, and admitted a ſtudent in St Salvator's college. His progreſs in the ſciences, which were then taught, was ſo great and ſo rapid, that he had no ſooner taken his degree of M. A. than he was choſen a profeſſor of philoſophy, and immediately began to read lectures in St Salvator's college. This muſt have been at a very early period of life; for he quitted St Andrews in the year 1583, when, according to Mackenzie, he had taught philoſophy for ſome time in that univerſity.

Not long before this period, the magiſtrates of Edinburgh having petitioned the king to erect a univerſity in that city, he granted them a charter under the great ſeal, allowing them all the privileges of a univerſity; and the college being built in 1582, they made choice of Mr Rollock to be their principal and profeſſor of divinity.

At what time he was admitted into holy orders, by whom he was ordained, or indeed whether he ever was ordained, has been the ſubject of ſome acrimonious controverſy; but it is a controverſy which we ſhall not revive; for, conſidering the manner in which orders were then conferred in Scotland, the queſtion is ſurely of very little importance. It is certain that he became famous in the univerſity, and among his countrymen in general, for his lectures in theology, and for the perſuaſive power of his preaching; for Calderwood affirms, that, in 1589, he and Mr Robert Bruce, another popular orator, made the Earl of Bothwel ſo ſenſible of his ſinful and vicious courſes, that, upon the 9th of November his lordſhip humbled himſelf upon his knees in the eaſt church in the forenoon, and in the high church in the afternoon, confeſſing before the people, with tears in his eyes, his diſſolute and licentious life, and promiſing to prove, for the future, another man.

In the year 1593, Principal Rollock and others were appointed by the ſtates of parliament to confer with the popiſh lords; and in the next year he was one of thoſe who, by the appointment of the general aſſembly of the church, met at Edinburgh in the month of May, and preſented to his majeſty a paper, entitled, *The dangers which, through the impunity of* EXCOMMUNICATED PAPISTS, TRAFFICKERS WITH THE SPANIARDS, *and other enemies of the religion and eſtate, are imminent to the true religion profeſſed within this realm, his Majeſty's perſon, crown, and liberty of this our native country.* His zeal againſt Papiſts was indeed ardent; and he ſeems to have adopted that judaical doctrine, which was embraced in ſome degree by all the reformers, that it is the duty of the civil magiſtrate to puniſh idolatry with death.

In the year 1595 he was nominated one of the commiſſioners for the viſitation of colleges. Theſe commiſſioners

Rollock.

missioners were empowered to visit all the colleges in the kingdom, to inquire into the doctrine and life of the several masters, the discipline used by them, the state of their rents and living, and to make their report to the next assembly.

In 1596, the factious behaviour of some of the ministers having drawn upon them the just resentment of the king, our principal was employed, on account of his moderation, to soften that resentment, and to turn his majesty's wrath against the *Papists!* In the year 1597, he was chosen moderator of the General Assembly—the highest dignity in the Scottish church; and he had the influence to get some great abuses redressed. Being one of fourteen ministers appointed by this assembly to take care of the affairs of the church, the first thing which he did was to procure an act of the legislature, restoring to the prelates their seats in parliament. He had here occasion for all his address; for he had to reconcile to this measure, not only such of the ministers as abhorred all kinds of subordination in the church, but likewise many of the lay lords, who were not delighted with the prospect of such associates in parliament as the Scotch prelates were at that period (A).

Though he spent the greater part of his life in conducting the affairs of the church, we have the authority of Spottiswood for saying, that he would have preferred retirement and study to the bustle of public life, especially at that period of faction and fanaticism, his feeble [illegible] was not [illegible] and his inclination [illegible] him to the college; and his [illegible] with the stone; [illegible] long bore with the fortitude [illegible] a Christian. He died at Edinburgh [illegible] 1598, in the [illegible] year of his [illegible] brethren, with [illegible] more [illegible] [illegible] A Commentary [illegible] Book of [illegible] on St Paul's Epistle to the [illegible] Edinburgh, 1590. 3. A Commentary on the [illegible], 4to, Edinburgh, 1591. 4. A Logical Analysis of St Paul's Epistle to the Romans, 8vo, Edinburgh, 1594. 5. Some Questions and Answers concerning the Covenant of Grace and the Sacraments, 8vo, Edinburgh, 1596. 6. A Treatise of Effectual Calling, 8vo, Edinburgh, 1597. 7. A Commentary on the Epistles of St Paul to the Thessalonians and Philemon, 8vo, Geneva, 1597. 8. A Commentary upon Fifteen Select Psalms, 8vo, Geneva, 1598. 9. A Commentary on the Gospel of St John, with a harmony of the Four Evangelists upon the Death, Resurrection, and Ascension of Jesus Christ, 8vo, Geneva, 1599. 10 Certain Sermons on Several Places of St Paul's Epistles, 8vo, Edinburgh, 1598. 11. A Commentary upon the Epistle to the Colossians, 8vo, published at Geneva, 16[illegible]. 12. A Logical Analysis of the Epistle to the Hebrews, 8vo, Edinburgh, 1605. 13. A Logical Analysis of the Epistle to the Galatians, 8vo, London, 1602. 14. A Commentary upon the Two First Chapters of the First Epistle of St Peter, 8vo, London, 1603. 15 and 16. A Treatise of Justification, and another of Excommunication, both in 8vo, London, 1604. All these works, except the sermons, are in Latin. That Principal Rollock was held in high estimation in the college over which he presided, is made at least probable by the following [illegible]taph:

Te Rollore, extincto, Urbs mæsta, Academia mæst[illegible];
Et tota exequiis Scotia mæsta tuis.
Uno in te nobis dederat Deus omnia, in uno
Te Deus eripuit omnia quæ dederat.

Roses.
Rota.

ROSES OTTER (or essential oil) OF. In the *Encyclopædia*, under the word ROSES, we have given one receipt for making this very high-priced perfume; and we shall here give another; which, whether it be as effectual or not, is at least simpler and less expensive. It is by an officer who was in the country where the Otter is prepared, and who assisted in making it himself; and is as follows:

"Take a very large glazed earthen or stone jar, or a large clean wooden cask; fill it with the leaves of the flowers of roses, very well picked, and freed from all seeds and stalks; pour on them as much pure spring water as will cover them, and set the vessel in the sun, in the morning at sun-rise, and let it stand till the evening, then take it into the house for the night; expose it, in this manner, for six or seven successive days, and, at the end of the third or fourth day, a number of particles, of a fine yellow oily matter, will float on the surface, which, in two or three days more, will gather into a scum, which is the otter of roses. This is taken up by some cotton, tied to the end of a piece of stick, and squeezed with the finger and thumb into a small phial, which is immediately well stopped; and this is repeated for some successive evenings, or while any of this fine essential oil rises to the surface of the water."

Dr Donald Monro, who communicated this receipt to the Royal Society of Edinburgh, says, that he has been informed, that some few drops of this essential oil have more than once been collected by distillation in London, in the same manner as the essential oils of other plants.

ROTA ARISTOTELICA, or *Aristotle's Wheel*, denotes a celebrated problem in mechanics, concerning the motion

(A) The constitution of the Scotch church was, at this period, a strange system of inconsistency and contradiction. It was, in fact, presbyterian; for ecclesiastical discipline was administered then, as at present, by kirk-sessions, presbyteries, and general assemblies; and there was not a reformed bishop in the kingdom. Whether provincial synods were then in use, the writer of this note does not at present recollect. The king, however, who was meditating the restoration of episcopacy, conferred the estates, or part of the estates, belonging to the different sees, upon the most eminent parochial ministers, and dignified them with the title of bishops; though it does not appear that they had any jurisdiction over their brethren; and though they were certainly not *ex officio* so much as moderators of the presbyteries within the bounds of which their churches were situated. These were the men for whom Mr Rollock exerted himself to obtain seats in the parliament.

Rota, Rowning.

tion or rotation of a wheel about its axis; so called because first noticed by Aristotle.

The difficulty is this. While a circle makes a revolution on its centre, advancing at the same time in a right line along a plane, it describes, on that plane, a right line which is equal to its circumference. Now if this circle, which may be called the deferent, carry with it another smaller circle, concentric with it, like the nave of a coach wheel; then this little circle, or nave, will describe a line in the time of the revolution, which shall be equal to that of the large wheel or circumference itself; because its centre advances in a right line as fast as that of the wheel does, being in reality the same with it.

The solution given by Aristotle, is no more than a good explication of the difficulty.

Galileo, who next attempted it, has recourse to an infinite number of infinitely little vacuities in the right line described by the two circles; and imagines that the little circle never applies its circumference to those vacuities; but in reality only applies it to a line equal to its own circumference; though it appears to have applied it to a much larger. But all this is nothing to the purpose.

Tacquet will have it, that the little circle, making its rotation more slowly than the great one, does on that account describe a line longer than its own circumference; yet without applying any point of its circumference to more than one point of its base. But this is no more satisfactory than the former.

After the fruitless attempts of so many great men, M. Dortous de Meyran, a French gentleman, had the good fortune to hit upon a solution, which he sent to the Academy of sciences; where being examined by Mess. de Louville and Soulmon, appointed for that purpose, they made their report that it was satisfactory. The solution is to this effect:

The wheel of a coach is only acted on, or drawn in a right line; its rotation or circular motion arises purely from the resistance of the ground upon which it is applied. Now this resistance is equal to the force which draws the wheel in the right line, inasmuch as it defeats that direction; of consequence the causes of the two motions, the one right and the other circular, are equal. And hence the wheel describes a right line on the ground equal to its circumference.

As for the nave of the wheel, the case is otherwise. It is drawn in a right line by the same force as the wheel; but it only turns round because the wheel does so, and can only turn in the same time with it. Hence it follows, that its circular velocity is less than that of the wheel, in the ratio of the two circumferences; and therefore its circular motion is less than the rectilinear one. Since then it necessarily describes a right line equal to that of the wheel, it can only do it partly by sliding, and partly by revolving, the sliding part being more or less as the nave itself is smaller or larger.—*Hutton's Dictionary.*

ROWNING (John), an ingenious English mathematician and philosopher, was fellow of Magdalen College, Cambridge, and afterwards Rector of Anderby in Lincolnshire, in the gift of that Society. He was a constant attendant at the meetings of the Spalding Society, and was a man of a great philosophical habit and turn of mind, though of a cheerful and companionable disposition. He had a good genius for mechanical contrivances in particular. In 1738 he printed at Cambridge, A Compendious System of Natural Philosophy, in 2 vols 8vo; a very ingenious work, which has gone through several editions. He had also two pieces inserted in the Philosophical Transactions, viz. 1. A Description of a Barometer, wherein the Scale of Variation may be increased at pleasure; vol. 38. p. 39. And, 2. Directions for making a Machine for finding the Roots of Equations universally, with the Manner of using it; vol. 60. p. 240.—Mr Rowning died at his lodgings in Carey-street, near Lincoln's-Inn Fields, the latter end of November 1771, at 72 years of age.

Though a very ingenious and pleasant man, he had but an unpromising and forbidding appearance: he was tall, stooping in the shoulders, and of a sallow down-looking countenance.

ROY-ROYAN, in Bengal, the chief officer in the revenue department, next to the Dewan under the native government.

RUTHERFORD (John, M. D.), one of the illustrious founders of the medical school in the university of Edinburgh, was the son of the Rev. Mr Rutherford minister of Yarrow, in the county of Selkirk, North Britain. He was born on the 1st August 1695, and received the rudiments of his education at the parish school of Selkirk; where, from his future proficiency, there is every reason to believe that he made a rapid progress in the knowledge of the Latin and Greek languages.

After the death of his father, he went to Edinburgh in 1708 or 1710, where, in the university, he applied himself to the study of classical literature, mathematics, and natural philosophy. The celebrated Dr was then so highly respected for his medical skill, that it is not improbable but that a laudable desire of obtaining a portion of similar fame may have turned the attention of young Rutherford to the study of medicine. Be that as it may, he engaged himself apprentice to Mr Alexander Nesbit, at that time an eminent surgeon in Edinburgh, with whom he remained till 1716, when he went to London. There he attended some hospitals, and the lectures read on anatomy by Dr Douglas, on surgery by André, and on materia medica by Strother.

After a year's residence in London, he returned to Edinburgh; and having settled his affairs in that city, he went to Leyden, which, from the lectures of Boerhaave, was then the most celebrated medical school in Europe. In 1719 he went into France, and was at the end of July in that year admitted to the degree of M.D. in the university of Rheims. He passed the following winter in Paris, chiefly for the sake of Winslow's private demonstrations in anatomy; and in 1720 he returned to Britain.

In 1721 he settled as a physician in Edinburgh; and soon afterwards Drs Rutherford, Sinclair, Plummer, and Innes, purchased a laboratory, where they prepared compound medicines. This was an art then but little known in Scotland; and as a commercial speculation, the laboratory must therefore have proved very advantageous to the partners. But they had higher objects in view than commerce. They demonstrated, as far as they were then known, the operations of chemistry

mistry to a [illegible]rous audience; [illegible] soon afterwards, by the ad[vi]ce of their old master Boerhaave, they extended their lectures to the other branches of physic. In 1725 they were appointed joint professors in the university; where, we believe, each, for some time, read lectures in every department of medical science, anatomy excepted, and carried forward their classes in rotation. The anatomical lectures were read by the elder Monro, who had been settled a year or two before them in Edinburgh, and whose eminence in that department is known to all Europe.

On the death of Dr Innes, a particular branch of medical science was allotted to each of the other three professors. Dr Plummer was appointed professor of chemistry and materia medica, Dr Sinclair of the institutes of physic, and Dr Rutherford of the practice; and thus was a regular medical school established in Edinburgh by Monro, Plummer, Sinclair, and Rutherford. The lectures on the institutes and practice of physic were then, and for many years afterwards, delivered in Latin; and such was Dr Rutherford's command of that language, that on every thing connected with medicine, he talked in it more fluently than in the language of his country.

Whether it was any improvement in the mode of medical education in Edinburgh to change the language of the lectures from Latin to English, is perhaps more than questionable. We have now dispersed over the country a number of illiterate men, practising as surgeons, and even as physicians, who never could have boasted of having gone through a regular course of medical instruction, had the lectures continued to be deli- [illegible] language in which they were begun. Foreigners too, would not have been under the necessity [illegible]ng a new language, before they could enter on [illegible] the cultivation of which they came to [illegible] though the medical classes might not have been so crowded perhaps as at present, the individuals composing them would have been at least as respectable. Whether Dr Rutherford reasoned in this way we know not; but he continued to lecture in Latin as long as he filled the practical chair.

Rutherford.

About the year 1748 he introduced a very great improvement in the course of medical education. Sensible that abstract lectures on the symptoms and the mode of treating various diseases, of which the students know little but the names, could scarcely be of any benefit, he had for some time encouraged his pupils to bring patients to him on Saturday, when he inquired into the nature of their diseases, and prescribed for them in the presence of the class. This gave rise to the course of *clinical* lectures; the utility of which was so obvious, that it was enacted, by a decree of the senate of the university, that no man should be admitted to an examination for his doctor's degree, who had not attended those lectures; to which an excellent hospital, then lately erected (see EDINBURGH, in the *Encyclopædia*), gave the professors every opportunity of doing ample justice. To men who mean to live by the practice of physic, and have no inordinate ambition to raise their fame by fanciful theories, this is perhaps the most valuable course of lectures that is given in Edinburgh; and if so, Dr Rutherford must be considered as one of the greatest benefactors of the medical school.

To untried theories in physic he was indeed no friend; and we have heard a favourite and very able pupil of his, who knew him well, and respected him highly, affirm that, to his knowledge, Dr Rutherford retained his professorship longer than he otherwise would have chosen to do; merely that he might keep out a speculatist, whom he knew to be aspiring to the practical chair. Finding at last in the late Dr John Gregory (see GREGORY, *Encycl.*) a successor entirely to his mind, he resigned to him in 1765, after having taught medicine in its different departments for upwards of forty years. He lived, after this period, loved by his friends, and revered by many eminent physicians, who had been his pupils, till 1779, when he died in Edinburgh, where he had spent the greater part of his life, in the 84th year of his age.

S.

SACCHAROMETER, the name given, by Mr Richardson of Hull, to an instrument invented by him for ascertaining the value of worts, and the strength of different kinds of malt liquors. In plain English, the name signifies a *measurer of sweetness*; and therefore, if etymology were to be attended to, the instrument should be employed merely as a measurer of the sweetness of worts. It is in fact best adapted for this purpose, being merely an hydrometer contrived to ascertain the specific gravity of worts, or rather to compare the weight of worts with that of equal quantities of the water employed in the brewery where the instrument is used.

Saccharometer.

The principle which suggested the invention of the instrument to Mr Richardson is as follows: The menstruum or water, employed by the brewer, becomes heavier or more dense by the addition of such parts of the materials as have been dissolved or extracted by, and thence incorporated with it: the operation of boiling, and its subsequent cooling, still adds to the density of it by evaporation; so that when it is submitted to the action of fermentation, it is more dense than at any other period.

In passing through this operation of nature, a remarkable alteration takes place. The fluid no sooner begins to ferment than its density begins to diminish; and as the fermentation is more or less perfect, the fermentable matter, whose accession has been traced by the increase of density, becomes more or less attenuated, and in lieu of every particle thus attenuated, a spirituous particle, of less density than water, is produced: so that when the liquor is again in a state of quietude, it is so much specifically lighter than it was before, as the action of fermentation has been capable of attenuating the component parts of its acquired density; and, indeed, were it practicable to attenuate the whole, the

liquor would become lighter or less dense than water; because the quantity of spirit produced from, and occupying the place of the fermentable matter, would diminish the density of the water in a degree bearing some proportion to that in which the latter had increased it.

From these facts, the reader, who is acquainted with hydrostatical principles, will be able to construct a saccharometer for himself. Brewers, who are strangers to these principles, we must refer to Mr Richardson's book for details, which our limits permit us not to give.

SAGITTA, in astronomy, the *Arrow* or *Dart*, a constellation of the northern hemisphere near the eagle, and one of the 48 old asterisms.

SAHARA, or, as it is sometimes written, ZAARA, the Great Desert, is a vast ocean of sand in the interior parts of Africa, which, with the lesser deserts of Bornou, Bilma, Barca, Sort, &c. is equal in extent to about one half of Europe. If the sand be considered as the ocean, the Sahara has its gulphs and bays, as also its islands, or OASES, fertile in groves and pastures, and in many instances containing a great population, subject to order and regular government.

The great body, or western division of this ocean, comprised between Fezzan and the Atlantic, is no less than 50 caravan journeys across, from north to south; or from 750 to 800 G. miles; and double that extent in length: without doubt the largest desert in the world. This division contains but a scanty portion of islands (or oases), and those also of small extent: but the eastern division has many, and some of them very large. Fezzan, Gadamis, Taboo, Ghanat, Agadez, Augela, Berdoa, are amongst the principal ones: besides which, there are a vast number of small ones. In effect, this is the part of Africa alluded to by Strabo, when he says from *Cneius Piso*, that Africa may be compared to a leopard's skin.

From the best inquiries that Mr Park could make when a kind of captive among the Moors at Ludamar, the Western Desert, he says, may be pronounced almost destitute of inhabitants; except where the scanty vegetation, which appears in certain spots, affords pasturage for the flocks of a few miserable Arabs, who wander from one well to another. In other places, where the supply of water and pasturage is more abundant, small parties of the Moors have taken up their residence. Here they live, in independent poverty, secure from the tyrannical government of Barbary. But the greater part of the desert, being totally destitute of water, is seldom visited by any human being; unless where the trading caravans trace out their toilsome and dangerous route across it. In some parts of this extensive waste, the ground is covered with low stunted shrubs, which serve as land marks for the caravans, and furnish the camels with a scanty forage. In other parts, the disconsolate wanderer, wherever he turns, sees nothing around him but a vast interminable expanse of sand and sky; a gloomy and barren void, where the eye finds no particular object to rest upon, and the mind is filled with painful apprehensions of perishing with thirst. Surrounded by this dreary solitude, the traveller sees the dead bodies of birds, that the violence of the wind has brought from happier regions; and, as he ruminates on the fearful length of his remaining passage, listens with horror to the voice of the driving blast; the only sound that interrupts the awful repose of the desert.

The few wild animals which inhabit these melancholy regions, are the antelope and the ostrich; their swiftness of foot enabling them to reach the distant watering-places. On the skirts of the desert, where the water is more plentiful, are found lions, panthers, elephants, and wild boars.

Of domestic animals, the only one that can endure the fatigue of crossing the desert is the camel. It is therefore the only beast of burden employed by the trading caravans which traverse, in different directions, from Barbary to Nigritia. The flesh of this useful and docile creature, though to our author's taste it was dry and unsavory, is preferred by the Moors to all others. The milk of the female, he says, is in universal esteem, and is indeed pleasant and nutritive.

That the desert has a dip towards the east, as well as the south, seems to be proved by the course of the Niger. Moreover, the highest points of North Africa, that is to say, the mountains of Mandinga and Atlas, are situated very far to the west. The desert, for the most part, abounds with salt. But we hear of salt mines only in the part contiguous to Nigritia, from whence salt is drawn for the use of those countries, as well as of the Moorish states adjoining; there being no salt in the Negro countries south of the Niger. There [illegible] the eastern part of the desert.

SAI, a large town on the banks of the Niger, or at least very near to that river, which Mr Park says strongly excited his curiosity. It is completely surrounded by two very deep trenches, at about two hundred yards distant from the walls. On the top of the trenches are a number of square towers; and the whole has the appearance of a regular fortification. Inquiring into the origin of this extraordinary entrenchment, our author learned from two of the town's people the following particulars; which, if true, furnish a mournful picture of the enormities of African wars.

About fifteen years before our traveller visited Sai, when the King of Bambarra desolated Maniana, the Dooty of Sai had two sons slain in battle, fighting in the king's cause. He had a third son living; and when the king demanded a further reinforcement of men, and this youth among the rest, the Dooty refused to send him. This conduct so enraged the king, that when he returned from Maniana, about the beginning of the rainy season, and found the Dooty protected by the inhabitants, he sat down before Sai with his army, and surrounded the town with the trenches which had attracted our author's notice. After a siege of two months, the towns-people became involved in all the horrors of famine; and whilst the king's army were feasting in their trenches, they saw with pleasure the miserable inhabitants of Sai devour the leaves and bark of the Bentang tree that stood in the middle of the town. Finding, however, that the besieged would sooner perish than surrender, the king had recourse to treachery. He promised, that if they would open the gates, no person should be put to death, nor suffer any injury, but the Dooty alone. The poor old man determined to sacrifice himself, for the sake of his fellow-citizens, and immediately walked over to the king's army, where he was put to death. His son, in attempting to escape, was caught and massacred in the trenches; and the rest of the towns-people were carried away captives, and sold as slaves to the different Negro traders.

traders. Sai is placed by Major Rennel in 14° N. Lat. and 3° 7′ West. Long.

SAINT CATHERINE, a Portuguese island in the South Sea, not far distant from the coast of Brazil. It was visited by La Perouse, who ascertained it to lie between 27° 19′ 10″, and 27° 49′ N. Lat. and its most northerly point to be in 49° 49′ longitude west from Paris. Its breadth from east to west is only two leagues; and it is separated from the main land by a channel only 200 toises broad. On the point which stretches furthest into this channel is situated the city of Nostra-Senora del Destero, the capital of the government, and the place of residence of the governor. It contains at most 3000 souls, and about 400 houses. Its appearance is exceedingly pleasant. According to Frezier's account, this island served, in 1712, as a retreat to vagabonds, who made their escape from different parts of the Brazils; who were only nominal subjects of Portugal, and who acknowledged no authority whatever. The country is so fertile, that they were able to subsist without any succour from the neighbouring colonies: and they were so destitute of money, that they could neither tempt the cupidity of the governor-general of the Brazils, nor inspire him with any desire of subduing them. The ships that touched at the island gave them in exchange for their provisions nothing but clothes and shirts, of which they were in the utmost want. It was not till about 17[illegible] that the court of Lisbon established a regular government in the island of St Catherine, and the parts of the continent adjacent. This government extends [illegible] and [illegible] from the river San Francisco [illegible] Grande; its population being about [illegible] there are so great a number of [illegible] that probably it will [illegible] considerable. The soil is ex[illegible] all sorts of fruit, vegetables, and corn, almost spontaneously. It is covered with trees of [illegible] green, but they are so interwoven with briars and creeping plants, that it is impossible to get through the forests otherwise than by opening a path with a hatchet. Danger is besides to be apprehended from snakes, whose bite is mortal. The habitations, both on the island and continent, are all close to the sea side. The woods that surround them are delightfully fragrant, owing to the great number of orange trees and other odoriferous trees and shrubs that they contain. But, notwithstanding all these advantages, the country is very poor, and totally destitute of manufactured commodities, so that the peasants are almost naked, or else covered with rags. Their soil, which is very fit for the cultivation of sugar, remains unproductive for the want of slaves, whom they are not rich enough to purchase. The whale fishery is very successful; but it is the property of the crown, and is farmed by a company at Lisbon, which has three considerable establishments upon the coast. Every year they kill about 400 whales; the produce of which, as well oil as spermaceti, is sent to Lisbon by the way of Rio-Janeiro. The inhabitants are idle spectators of this fishery, from which they derive not the smallest advantage. La Perouse gives a very amiable picture, however, of their hospitality to strangers.

SALT. See CHEMISTRY *Index*, in this *Suppl.*

SALT-Mines of *Vielicza*, near Cracow in Poland, are very extraordinary caverns; for a description of which we referred, in the article SALT (*Encycl.*) to M. Bernard in the *Journal de Physique* for the year 1786. Some of our readers have complained of this, and requested an account of them in the *Supplement*. With this request we shall comply, by giving them Mr Wraxall's description of these caverns *.

"After being let down (says he) by a rope to the depth of 230 feet, our conductors led us through galleries, which, for loftiness and breadth, seemed rather to resemble the avenues to some subterranean palace, than passages cut in a mine. They were perfectly dry in every part, and terminated in two chapels composed entirely of salt, hewn out of the solid mass. The images which adorn the altars, as well as the pillars and ornaments, were all of the same transparent materials; the points and spars of which, reflecting the rays of light from the lamps which the guides held in their hands, produced an effect equally novel and beautiful. Descending lower into the earth by means of ladders, I found myself in an immense hall or cavern of salt, many hundred feet in height, length, and dimensions, the floor and sides of which were cut with exact regularity. A thousand persons might dine in it without inconvenience, and the eye in vain attempted to trace or define its limits. Nothing could be more sublime than this vast subterranean apartment, illuminated by flambeaux, which faintly discover its prodigious magnitude, and leave the imagination at liberty to enlarge it indefinitely. After remaining about two hours and a half under ground, I was drawn up again in three minutes with the greatest facility."

* Memoirs of the Courts of Berlin, Dresden, Warsaw, and Vienna.

SALTPETRE (see *Nitre*, CHEMISTRY-*Index*, in this *Suppl.*) is an article of so much importance, and sometimes so difficult to be had, that it is wonderful more attention is not bestowed in endeavouring to discover some easy method to increase the quantity. Such a method has been long practised by the farmers of Appenzell in Switzerland. In so hilly a country, most houses and stables are built on slopes, one side of the edifice resting on the hill, and the other being supported by two strong posts, elevated two or three feet above the ground; so that the air has a free current under the building. Immediately under the stable a pit is dug, usually occupying both in breadth and length the whole space of ground covered by the building; and instead of the clayey earth which is dug out, the pit is filled up with sandy soil. This is the whole process, and all the rest is done by nature. The animal water, which is continually oozing through the planks of the floor, having drenched the earth contained in the pit for the space of two or three years, the latter is emptied, and the saltpetre is refined and prepared in the usual manner.

That manner, however, is not the best; and the French chemists, during the incessant wars occasioned by the revolution, have, for the sake of supplying their armies with gunpowder, turned their attention to the best method of refining saltpetre. The following are directions given for this purpose by Chaptal, Champy, and Bonjour.

The crude saltpetre is to be beaten small with mallets, in order that the water may more easily attack every part of the mass. The saltpetre is then to be put into tubs, five or six hundred pounds in each tub. Twenty *per cent.* of water is to be poured into each tub, and

Saltpetre. and the mixture well stirred. It must be left to macerate or digest until the specific gravity of the fluid ceases to augment. Six or seven hours are sufficient for this last operation, and the water acquires the density of between 25 and 35 degrees. (Sp. gr 1.21, and 1.300, ascertained by Baume's hydrometer. See HYDROMETER, *Suppl.*

The first water must then be poured off, and a second portion of water must be poured on the same saltpetre amounting to 10 *per cent.*; after which the mixture must be stirred up, suffered to macerate for one hour, and the fluid drawn or poured off.

Five *per cent.* of water must then be poured on the saltpetre; and after stirring the whole, the fluid must be immediately drawn off.

When the water is drained from the saltpetre, the salt must be thrown into a boiler containing 50 *per cent.* of boiling water. When the solution is made, it will mark between 66 and 68 degrees of the hydrometer. (Sp. gr. 1.848, and 1.898.)

The solution is to be poured into a proper vessel, where it deposits by cooling about two-thirds of the saltpetre originally taken. The precipitation begins in about half an hour, and terminates in between four and six hours. But as it is of importance to obtain the saltpetre in small needles, because in this form it is more easily dried, it is necessary to agitate the fluid during the whole time of the crystallization. A slight motion is communicated to this liquid mass by a kind of rake; in consequence of which the crystals are deposited in very slender needles.

In proportion as the crystals fall down, they are scraped to the borders of the vessel, whence they are taken with a skimmer, and thrown to drain in baskets placed on tressels, in such a manner that the water which passes through may either fall into the crystallizing vessel, or be received in basons placed underneath.

The saltpetre is afterwards put into wooden vessels in the form of a mill-hopper or inverted pyramid with a double bottom. The upper bottom is placed two inches above the lower on wooden ledges, and has many small perforations through which water may pass to the lower bottom, which likewise affords a passage by one single aperture. A reservoir is placed beneath. The crystallized saltpetre is washed in these vessels with 5 *per cent.* of water; which water is afterwards employed in the solution of saltpetre in subsequent operations.

The saltpetre, after sufficient draining, and being dried by exposure to the air upon tables for several hours, may then be employed in the manufacture of gunpowder.

But when it is required to use the saltpetre in the speedy and immediate manufacture of gunpowder, it must be dried much more strongly. This may be effected in a stove, or more simply by heating it in a flat metallic vessel. For this purpose the saltpetre is to be put into the vessel to the depth of five or six inches, and heated to 40 or 50 degrees of the thermometer (or about 135° of Fahrenheit). The saltpetre is to be stirred for two or three hours, and dried so much that, when strongly pressed in the hand, it shall acquire no consistence, nor adhere together, but resemble a very fine dry sand. This degree of dryness is not required when the powder is made by pounding.

From these circumstances, we find that two saline liquids remain after the operation; (1) the water from the washing; and (2) that from the crystallizing vessels.

We have already remarked, that the washing of the saltpetre is performed in three successive operations, in which, upon the whole, the quantity of fluid made use of amounts to 35 *per cent* of the weight of the crude saltpetre. These washings are established on the principle, that cold water dissolves the muriats of soda, and the earthy nitrats and muriats, together with the colouring principle, but scarcely attacks the nitrat of potash.

The water of these three washings therefore contains the muriat of soda, the earthy salts, the colouring principle, and a small quantity of nitrat of potash; the amount of which is in proportion to that of the muriat of soda, which determines its solution.

The water of the crystallizing vessels contains a portion of the muriats of soda, and of the earthy salts which escaped the operation of washing, and a quantity of nitrat of potash, which is more considerable than that of the former solution.

The waters made use of at the end of the operation, to whiten and wash the crystals deposited in the pyramidal vessel, contain nothing but a small quantity of nitrat of potash.

These waters are therefore very different in their nature. The water of the washings is really a mother water. It must be collected in [illegible], and treated with potash by the known processes. It must be evaporated to 66 degrees (or 1,848 to [illegible]) [illegible] the muriat of soda as it falls. This [illegible] to be saturated with 2 or 3 *per cent.* of potash, [illegible] decanted, and poured i[illegible] where 10 *per cent.* of water is to [illegible] added, to keep the whole of the muriat of soda [illegible]ded.

The waters whic[illegible] thus obtained by treatment of the mother water, may be mixed with the water of the first crystallization. From these the marine salt may be separated by simple evaporation; and the nitrat of potash, which they hold in solution, may be afterwards obtained by cooling.

The small quantity of water made use of to wash and whiten the refined saltpetre, contains nothing but the nitrat of potash: it may therefore be used in the solution of the saltpetre when taken from the tubs.

From this description it follows, that a manufactory for the speedy refining of saltpetre ought to be provided with (1) mallets or rammers for pounding the saltpetre; (2) tubs for washing; (3) a boiler for solution; (4) a crystallizing vessel of copper or lead, in which the saltpetre is to be obtained by cooling; (5) baskets to drain the crystals; (6) a wooden case or hopper for the last washing and draining the saltpetre; (7) scales and weights for weighing; (8) hydrometers and thermometers, to ascertain densities and temperatures; (9) rakes to agitate the liquor in the crystallizing vessel; (10) skimmers to take out the crystals, and convey them to the baskets; (11) syphons or hand pumps to empty the boilers.

The number and dimensions of these several articles must vary according to the quantity of saltpetre intended to be refined.

Saltpetre, Sandarac. GUM-SANDARAC, is said, in the *Encyclopædia*, to

Sandarac, Sanders.

to be produced from a species of juniper. This was long the common opinion; but M. Schousboe has lately proved(A) it to be a mistake The *juniperus communis*, from which many have derived this gum, does not grow in Africa; and Sandarac seems to belong exclusively to that part of the world. The gum sandarac of our shops is brought from the southern provinces of the kingdom of Morocco. About six or seven hundred quintals of it are exported every year from Santa Cruz, Mogador, and Saffy. In the language of the country it is called *el grassa*. The tree which produces it is a *Thuia*, found also by M. Vahl in the kingdom of Tunis. It was made known several years ago by Dr Shaw, who named it *Cypressus fructu quadrivalvi, Equiseti instar articulatis*; but neither of these learned men was acquainted with the economical use of this tree; probably because, being not common in the northern part of Barbary, the inhabitants find little advantage in collecting the resin which exudes from it.

M. Schousboe, who saw the species of *thuia* in question, says that it does not rise to more than the height of twenty or thirty feet at most, and that the diameter of its trunk does not exceed ten or twelve inches. It distinguishes itself, on the first view, from the two other species of the same genus, cultivated in gardens, by having a very distinct trunk, and the figure of a real tree; whereas in the latter the branches rise from the root, which gives them the appearance rather of bushes. Its branches also are [illegible] articulated and brittle. Its flowers, which are not very apparent, shew themselves in April [illegible] which are of a spherical form, ripen in [illegible] branch of th tree is held to the [illegible] to be [illegible] with a [illegible] which contain the resin. When [illegible] the summer months, [illegible] from the trunk and branches, as [illegible] other coniferous trees. This resin is the [illegible] by the inhabitants of the country, and carried to the [illegible] is transported to Europe. It is employed in making some kinds of sealing-wax, and in different sorts of varnish. In 1793 a hundred weight of it cost in Morocco from 13 to 15½ piastres, which make from about L. 3, 5s. to L. 3, 7s. 6d. sterling. The duty on exportation was about 7s. 6d. sterling per quintal.

Sandarac, to be good, must be of a bright-yellow colour, pure and transparent. It is an article very difficult to be adulterated. Care, however, must be taken, that the Moors do not mix with it too much sand. It is probable that a tree of the same kind produces the gum sandarac of Senegal, which is exported in pretty considerable quantities.

SANDERS-RED (see PTEROCARPUS, *Encycl.*) is used as a dye stuff, but generally in a manner which is very disadvantageous. In Crell's Chemical Annals are given, by Mr Vogler, the following directions for dyeing with this wood.

1. Into a solution of tin made with aquafortis (nitric acid), and mixed with three times as much salt water, put clean-washed wool, silk, linen, and cotton. After six hours, take them out, and wash them carefully in three different quantities of clean cold water, wringing them well each time. Let them dry, and then put half the quantity of each article into the spirituous tincture of red sanders, hereafter described in n 6. letting them soak therein, without heat, from half an hour to an hour. To ascertain the superiority of his different processes, the other half of each article must be boiled in the tincture of sanders mixed with water, described in n° 7. a bare quarter of an hour. After being taken out, wrung, and dried in the shade, all of them will be dyed throughout of a fine rich poppy-colour.

2. Take three drams of powdered alum, and dissolve it in twelve ounces of clean hot water. Into this solution, while yet warm, put some well-washed wool, silk, linen, and cotton. After suffering them to remain therein for the space of twelve hours, take them out, wash them well in three quantities of clean cold water (wringing them each time), and dry them. Then steep the half of each article in the cold spirituous tincture of sanders (n° 6.), from half an hour to an hour; and boil the other half of each in the diluted tincture of sanders (n° 7.) for the space of six or seven minutes. After being taken out, wrung, and dried in the shade, they will be found to have acquired a very beautiful and rich scarlet colour.

3. Dissolve three drams of blue vitriol, or vitriol of copper, in twelve ounces of hot water. Steep in this solution, for twelve hours, wool, silk, linen, or cotton; and having sufficiently washed the stuff in clean cold water, immerse the one half of it in the spirituous tincture of sanders (n° 6.), from half an hour to an hour; and boil the other half of each for six or seven minutes in the diluted tincture, n° 7. Being then taken out, wrung, and dried in the shade, as before, they will have acquired a beautiful, rich, bright, crimson colour.

4. Steep wool, silk, linen, and cotton, which has been well washed, during twelve hours, in a solution of three drams of white vitriol, or vitriol of zinc, in twelve ounces of hot water. After being taken out, well washed in clean cold water, and dried, immerse one half of each in the cold spirituous tincture of sanders (n° 6.) and boil the other half in the diluted tincture (n° 7.) as before. When taken out, wrung, and dried, they will be of a fine, rich, deep crimson colour.

5. Dissolve three drams of common green vitriol, or vitriol of iron, in twelve ounces of hot water. Steep well-washed wool, silk, linen, and cotton, in the solution, for the space of twelve hours. When taken out, washed several times in clean cold water, and dried, treat them, as in n° 4. and they will be generally found to be of a fine, rich, deep violet colour; though, on repeating his experiments, our author sometimes found the colour a dark brownish red.

The tincture in which the stuffs are to be dyed must be prepared in the following manner.

6. Take half an ounce of red sanders wood, beat or ground to powder, as it is sold at the colour shops or druggists. Having put it into a large glass bottle, pour upon it twelve ounces of malt spirit or common brandy; then cork the bottle, and set it in a moderately-warm place. In the space of 48 hours, the spirit will have extracted all the colouring matter from the red sanders, and thereby acquired a bright red colour. The bottle

(A) In a Danish Journal, intitled, *The Physical, Medical, and Economical Library*, Part III. 1799.

should be often shaken during the digestion: and the tincture, thus prepared, may be used for dyeing without heat, and without separating the powdered sanders from the liquor. The articles to be dyed (after the application of the proper mordants, n° 1, 2, 3, 4, 5) are to be steeped in the tincture for half an hour, or a whole hour: they are then to be taken out, wrung, and dried in the shade. This tincture does not lose its dyeing quality by age; but dyes substances, after being kept a long time, almost as well as when it is just made. Its colouring power is indeed weakened by the frequent immersion and dyeing of different articles in it; and when that is the case, it must be again digested with some fresh sanders-wood.

7. Mix the spirituous tincture of sanders, just described, with from six to ten times as much clean cold water. The mixture was made by our author without any separation of the colouring particles worth noticing; and in this diluted tincture, the various articles (having their proper mordants first applied, n° 1, 2, 3, 4, 5) were boiled, as before mentioned. Linen and cotton, by being dipped in glue-water, after the application of the mordants, acquire, in this diluted tincture, a much deeper and richer colour.

If a very fine and bright colour be desired, the above spirituous tincture of sanders should not be too old, nor should the digestion be protracted beyond 48 hours; for after that period, the spirit appears to extract brown and yellow colouring particles from the wood. The powder of sanders need not be separated from the diluted tincture which is made use of by boiling; nor is it absolutely necessary to wash the articles in cold water after they are dyed; as the powder which adheres to them may easily be taken off by rubbing and shaking. M. Vogler, however, found it advantageous, after the articles were taken out of the dye, and wrung, to keep them for a few minutes in a cold solution of half an ounce of common salt, and a quarter of an ounce of alum, in 12 ounces of pure water. In this case, they should afterwards be washed several times in clean cold water, then wrung and dried in the shade. By this method the colours are not only more beautiful, but are also more permanent. All the articles of wool, silk, linen, and cotton, which were dyed as is above mentioned, bore perfectly well the test of alkaline ley, soap, and acids; but, by exposure to the open air and the sun, the colours were more easily discharged, especially from linen and cotton.

N. B. Red sanders, by being ground to a fine powder, answers much better for dyeing by this process, than when it is merely cut into small pieces; but it must be remarked, that the powder of red sanders which is sold at the shops is sometimes adulterated, by being mixed with other substances, and moistened with acids. The best kind is not light, but rather heavy; and is not of a dark red colour, but clear and bright.

Goodwin SANDS, famous sand banks off the coast of Kent, lying between the north and south Foreland; and as they run parallel with the coast for three leagues together, at about two leagues and a half distant from it, they add to the security of that capacious road the Downs; for while the land shelters ships with the wind from south-west to north-west only, these sands break all the force of the sea when the wind is at east south-east. The most dangerous wind, when blowing hard on the Downs, is the south-south-west. These sands occupy the space that was formerly a large tract of low ground belonging to Godwyn Earl of Kent, father of King Harold; and which being afterward given to the monastery of St Augustin at Canterbury, the abbot neglecting to keep in repair the wall that defended it from the sea, the whole track was drowned, according to Salmon, in the year 1100, leaving these sands, upon which so many ships have since been wrecked.

SANSANDING, a town in Africa, situated near the banks of the Niger, in Lat. 14° 24′ N. and 2° 23′ W. Long. It is inhabited by Moors and Negroes to the number of from eight to ten thousand. The Negroes are kind, hospitable, and credulous; the Moors are at Sansanding, as everywhere else in the interior parts of Africa, fanatical, bigotted, and cruel.

SAP, or Sapp, in building, as to sap a wall, &c. is to dig out the ground from beneath it, so as to bring it down all at once for want of support.

SAPHAN, in zoology. See Mus, *Encycl.* p. 467.

SAPHIES, a kind of charms, consisting of some scrap of writing, which the credulous Negroes believe capable of protecting them from all evil. The writers of saphies are generally Moors, who sell scraps of the Koran for this purpose to a people who believe not either in the Koran or the prophet. Accordingly, any piece of writing may be sold as a saphie; and Mr Park found the Negroes disposed to place greater confidence in the saphies of a Christian than in those of a Moor. The manner in which these charms are supposed to operate, will be learned [illegible]

Mr Park, being [illegible] near the Niger, and [illegible] hearing that he was a [illegible] of procuring a saphie [illegible] out his walha or writing board [illegible] our author) that he would [illegible] if I would write him a saphie to protect him from wicked men. The proposal was of too great consequence to me to be refused; I therefore wrote the board full from top to bottom, on both sides; and my landlord, to be certain of having the whole force of the charm, washed the writing from the board into a calabash with a little water; and having said a few prayers over it, drank this powerful draught; after which, lest a single word should escape, he licked the board until it was quite dry. A saphie writer was a man of too great consequence to be long concealed: the important information was carried to the Dooty, who sent his son with half a sheet of writing-paper, desiring me to write him a *naphula saphie* (a charm to procure wealth). He brought me, as a present, some meal and milk; and when I had finished the saphie, and read it to him with an audible voice, he seemed highly satisfied with his bargain, and promised to bring me in the morning some milk for my breakfast. Our author contrived to turn this absurd superstition to his own advantage, by writing saphies for his subsistence when his money was exhausted.

SARACOLETS, a Negro nation occupying the lands situated between the rivers of Senegal and Gambia. They are a laborious people, cultivate their lands with care, are plentifully supplied with all the necessaries of life, and inhabit handsome and well built villages; their houses, of a circular form, are for the most part terra-

Saracolets, Saville.

ced; the others are covered with reeds as at Senegal; they are inclosed with a mud wall a foot thick, and the villages are surrounded with one of stone and earth of double that solidity. There are several gates, which are guarded at night for fear of a surprise. This nation is remarkably brave, and it is very uncommon to find a Saracolet slave. They always defend themselves with advantage against their assailants. Such Saracolets as are exposed to sale may be safely purchased, for (excepting when they are at war with the Poules) none are to be met with but such as have been condemned by the laws for some misdemeanour; in such case, these wretches could not escape slavery even by taking refuge in their own country; for they would be restored to their masters, or would be put to death, if the convoy should have failed. The religious principles of this people are nearly allied to Mahometanism, and still more to natural religion. They acknowledge one God, and believe that those who steal, or are guilty of any crime, are eternally punished. They admit a plurality of wives, and believe their souls to be immortal like their own. They think lightly of [illegible]; for as they [illegible] themselves several wives, they are not so unjust as to punish women who [illegible] their favours among several gallants; [illegible] exchange is then permitted, one [illegible] for another, unless she be free, or [illegible] country. In this last case, the French [illegible] the [illegible] of the [illegible]

[illegible]

[illegible] same place [illegible] was a cycle like to that of Meto.

SARRASIN, or SARRAZIN, in fortification, a kind of port-cullis, otherwise called [illegible] hung with ropes over the gate of a town or fortress, to be let fall in case of a surprise.

SAVILLE (Sir Henry), a very learned Englishman, the second son of Henry Saville, Esq; was born at Bradley, near Halifax, in Yorkshire, November the 30th, 1549. He was entered of Merton College, Oxford, in 1561, where he took the degrees in arts, and was chosen fellow. When he proceeded master of arts in 1570, he read for that degree on the Almagest of Ptolemy, which procured him the reputation of a man eminently skilled in mathematics and the Greek language; in the former of which he voluntarily read a public lecture in the university for some time.

In 1578 he travelled into France and other countries; where, diligently improving himself in all useful learning, in languages, and the knowledge of the world, he became a most accomplished gentleman. At his return, he was made tutor in the Greek tongue to Queen Elizabeth, who had a great esteem and liking for him.

Saville.

In 1585 he was made warden of Merton College, which he governed six and thirty years with great honour, and improved it by all the means in his power.—In 1596 he was chosen provost of Eton College; which he filled with many learned men.—James the First, upon his accession to the crown of England, expressed a great regard for him, and would have preferred him either in church or state; but Saville declined it, and only accepted the ceremony of knighthood from the king at Windsor in 1604. His only son Henry dying about that time, he thenceforth devoted his fortune to the promoting of learning. Among other things, in 1619, he founded, in the university of Oxford, two lectures, or professorships, one in geometry, the other in astronomy; which he endowed with a salary of 160l. a-year each, besides a legacy of 600l. to purchase more lands for the same use. He also furnished a library with mathematical books, near the mathematical school, for the use of his professors; and gave 100l. to the mathematical chest of his own appointing: adding afterwards a legacy of 40l. a-year to the same chest, to the university, and to his professors jointly. He likewise gave 120l. towards the new building of the schools, beside several rare manuscripts and printed books to the Bodleian library; and a good quantity of Greek types to the printing-press at Oxford.

After a life thus spent in the encouragement and promotion of science and literature in general, he died at Eton College the 19th of February 1622, in the 73d year of his age, and was buried in the chapel there. On this occasion, the university of Oxford paid him the greatest honours, by having a public speech and verses made in his praise, which were published soon after in 4to, under the title of *Ultima Linea Savilii*.

As to the character of Saville, the highest encomiums are bestowed on him by all the learned of his time: by Casaubon, Mercerus, Meibomius, Joseph Scaliger, and especially the learned Bishop Montague; who, in his *Diatribæ* upon Selden's History of Tythes, styles him, "that magazine of learning, whose memory shall be honourable amongst not only the learned, but the righteous for ever."

Several noble instances of his munificence to the republic of letters have already been mentioned; in the account of his publications many more, and even greater, will appear. These are,

1. Four Books of the Histories of Cornelius Tacitus, and the Life of Agricola; with Notes upon them, in folio, dedicated to Queen Elizabeth, 1581.—2. A View of certain Military Matters, or Commentaries concerning Roman Warfare, 1598.—3. *Rerum Anglicarum Scriptores post Bedam*, &c. 1596. This is a collection of the best writers of our English history; to which he added chronological tables at the end, from Julius Cæsar to William the Conqueror.—4. The Works of St Chrysostom, in Greek, in 8 vols folio, 1613. This is a very fine edition, and composed with great cost and labour. [illegible] preface he says, "that having himself visited, [illegible] years before, all the public and private libraries in Britain, and copied out thence whatever he thought useful to this design, he then sent some learned men into France, Germany, Italy,

Saville. Sauffure.

Italy, and the East, to transcribe such parts as he had not already, and to collate the others with the best manuscripts." At the same time, he makes his acknowledgments to several eminent men for their assistance; as Thuanus, Velserus, Schottus, Casaubon, Ducæus, Gruter, Hoeschelius, &c. In the 8th volume are inserted Sir Henry Saville's own notes, with those of other learned men. The whole charge of this edition, including the several sums paid to learned men, at home and abroad, employed in finding out, transcribing, and collating the best manuscripts, is said to have amounted to no less than 8000l. Several editions of this work were afterwards published at Paris.—5. In 1618 he published a Latin work, written by Thomas Bradwardin, archbishop of Canterbury, against Pelagius, intitled, *De Causa Dei contra Pelagium, et de virtute causarum*; to which he prefixed the life of Bradwardin.—6. In 1621 he published a collection of his own Mathematical Lectures on Euclid's Elements, in 4to.—7. *Oratio coram Elizabetha Regina Oxoniæ habita*, anno 1592. Printed at Oxford in 1658, in 4to.—8. He translated into Latin King James's Apology for the Oath of Allegiance. He also left several manuscripts behind him, written by order of King James; all which are in the Bodleian library. He wrote notes likewise upon the margin of many books in his library, particularly Eusebius's Ecclesiastical History; which were afterwards used by Valesius, in his edition of that work in 1659.—Four of his letters to Camden are published by Smith, among Camden's Letters, 1691, 4to.

SAUSSURE (Horace Benedict de) was born at Geneva in 1740. His father, an intelligent farmer, to whom we are indebted for some memoirs relating to rural economy, resided at Conches, a place situated on the banks of the Arve, at the distance of half a league from Geneva; and this country life, added to an active education, expanded no doubt in young De Sauffure that physical strength so necessary to the naturalist who devotes himself to travel. He repaired daily to town to enjoy the advantage of public instruction; and as he lived at the bottom of Saleve, a mountain which he has since rendered celebrated, he amused himself frequently with ascending its steep and rugged sides. Being thus surrounded by the phenomena of nature, and at the same time aided by study, he conceived a taste for natural history, and avoided the error both of the learned, who form theories without having been out of their closets, and of those farmers who, living too near to Nature, are incapable of admiring her beauties.

His earliest passion was botany: a variegated soil, abundant in plants of different kinds, invites the inhabitant of the banks of the Leman to cultivate that agreeable science. This taste produced an intimacy between De Sauffure and the great Haller. He paid him a visit in the year 1764, during his retreat to Bex; and he relates in his travels how much he admired that astonishing man, who excelled in every part of the natural sciences. De Sauffure was induced also to study the vegetable kingdom, by his connection with Ch. Bonnet, who had married his aunt, and who soon set a just value on the rising talents of his nephew. Bonnet (See his life in this *Suppl.*) was then employed on the leaves of plants. De Sauffure studied these organs of vegetables also, and he published the result of his researches, under the title of Observations on the Bark of Leaves. This small work, which appeared soon after the year 1762, contains new observations on the epidermis of leaves, and in particular on the miliary glands by which they are covered.

About that period, the place of professor of philosophy falling vacant, it was conferred upon De Sauffure, who was then only twenty one years of age. Experience proves, that if premature rewards extinguish the zeal of those who labour merely for themselves, they, on the contrary, strengthen it in those who labour only for truth. At that time the two professors of philosophy at Geneva taught physics and logic alternately. De Sauffure discharged this double task with equal success. He gave to his course of logic a practical, and, as one may say, experimental turn; and his method of teaching, which began by studying the senses to arrive at the general laws of the understanding, announced already an able observer of nature.

Physics, however, were the part for which he had the greatest taste, and which conducted him to the study of chemistry and mineralogy. He then began his travels through the mountains; not now to examine their vegetable productions, but to study the mountains themselves, either in the stones of which they are composed, or the disposition of their masses. Geology, a science which was then scarcely in existence, added charms to his numerous excursions through the Alps; and it was then that the talents of the great philosopher were really displayed. During the first fifteen or twenty years of [illegible] by turns in [illegible] traversing the [illegible] of Geneva. He [illegible] side as far as [illegible] to Piedmont. [illegible] ney to [illegible] volcanoes [illegible] After [illegible] were not [illegible] particular [illegible] of studying nature [illegible] every instrument that [illegible] set out until he had [illegible] and observations he intended to make. He often says in his works that he had found this method exceedingly useful.

In the year 1779 he published the first volume of his Travels through the Alps; which contains a minute description of the environs of Geneva, and an excursion as far as Chamouni, a village at the bottom of Mont Blanc. Philosophers will read there with pleasure the description of his Magnetometer. The more he examined mountains, the more was he sensible of the importance of mineralogy. To study it with advantage, he learned the German language; and it may be seen, in the last volumes of his Travels, how much new mineralogical knowledge he had acquired.

Amidst his numerous excursions through the Alps, and at the time of the political troubles of Geneva in 1782, he found means to make his beautiful experiments on hygrometry, which he published in 1783, under the title of *Essays on Hygrometry*. This work, the best that ever came from his pen, established fully his reputation as a philosopher. We are indebted to him also for the invention of a new hygrometer. Deluc

had

Sauffure. had already invented his whalebone hygrometer; and on that account there arofe between him and De Sauffure a fort of conteft, which degenerated into a pretty violent difpute.

In the year 17[illegible]6 De Sauffure refigned the profeffor's chair, which he had filled for about twenty five years, to his pupil and fellow-labourer Pictet, who difcharged with reputation the duties of an office rendered more difficult by fucceeding fo eminent a philofopher.

When De Sauffure was invited by the ftate to take a fhare in the public education, he made it one of the fubjects of his meditations, and prefented the plan of a reform in the education of Geneva; the tendency of which was, to make young people early acquainted with the natural fciences and mathematics. He even wifhed that their phyfical education fhould not be neglected, and with that view propofed gymnaftic exercifes. This plan, which excited much attention in a city where every one is convinced of the imp[illegible] of education, found admirers and partifans; but the poverty of its pecuniary refources was an obftacle to every impo[illegible] innovation. It [illegible] altering [illegible] blifhed [illegible], and that things might [illegible] the whole. The Genevefe were [illegible] their old fyftem of education; and they [illegible] it had not only proved [illegible] generally amongft [illegible] talents of feveral [illegible] (A).

[illegible] confined to [illegible] the [illegible] who have [illegible]. His [illegible] extenfive [illegible] for [illegible] and [illegible] alfo fome [illegible] on electricity, and a defcription of his electrometer, one of the moft perfect that we have. We are indebted to him alfo for feveral inftruments of meafurement, fuch as his cyanometer, deftined to meafure the degree of the bluenefs of the heavens, which varies according to the elevation of the obferver; his diaphanometer (See Photometer, *Suppl.*), and his anemometer, which, by means of a kind of balance, meafures the force of the wind.

Some years after the publication of the fecond volume of his Travels, De Sauffure was admitted as a foreign affociate of the Academy of Sciences of Paris; and Geneva could then boaft of having two of its citizens in that clafs, which confifted only of feven members. De Sauffure not only did honour to his country; he loved and ferved it. He was the founder of the Society of Arts, to which Geneva is indebted for the high ftate of profperity it has attained within the laft thirty years. He prefided over that fociety till the laft Sauffure. moment of his life; and one of his fondeft wifhes was the prefervation of this ufeful eftablifhment.

In confequence of M. de Sauffure's fatiguing labours in the Council of Two Hundred, of which he was a member, and afterwards in the National Affembly, his health began to be deranged, and in 1794 he was almoft deprived of the total ufe of his limbs by a ftroke of the palfy. However painful his condition then m[illegible] be, his mind ftill preferved its activity; and after that accident he revifed the two laft volumes of his Travels, which appeared in 1796. They contain an account of his excurfions to the mountains of Piedmont and Swifferland, and in particular of his journey to the fummit of Mont Blanc. Thefe volumes, inftead of exhibiting any marks of his malady, prefent an enormous mafs of new facts and obfervations of the utmoft importance to phyfics.

He rendered alfo an important fervice to that fcience by publifhing the *Agenda*, which terminate his fourth volume, and in which that great man, furviving himfelf, conducts the young naturalift through the middle of mountains, and teaches him the method of obferving them with advantage. Thefe *Agenda* are a proof of his genius, and of the ftrength of mind which he retained amidft his fufferings. It was alfo during his illnefs that he directed the experiments made on the height of the bed of the Arve, and that he publifhed Obfervations on the Fufibility of Stones by the Blow-pipe, which were inferted in the *Journal de Phyfique*.

Having gone for the fake of his health to the baths of Plombiers, he ftill obferved the mountains at a diftance, and caufed to be brought to him fpecimens of the ftrata which he perceived in the fteepeft rocks. He had announced that he would conclude his travels with fome ideas on the primitive ftate of the earth; but the more he acquired new facts, and the more he meditated on the fubject, the more uncertain did his opinions become in regard to thofe grand revolutions which preceded the prefent epoch. In general he was a Neptunian; that is to fay, afcribed all the revolutions of our globe to water. He admitted the poffibility of the mountains having been thrown up by elaftic fluids difengaged from the cavities of the earth.

Though the ftate of his health began gradually to become worfe, he ftill entertained hopes of recovery; and the French government having appointed him profeffor of philofophy at the Special School of Paris, he did not defpair of being one day able to fill that office; but his ftrength was exhaufted, a general languor fucceeded the vigour he had always enjoyed, his flow and embarraffed pronunciation no longer correfponded with the vivacity of his mind, and formed a melancholy contraft with the pleafantnefs by which he had been formerly diftinguifhed. It was a painful fpectacle to fee this great man reduced thus to imbecility at an age when meditation is beneficial, and when he might have enjoyed the fruits of his reputation and labours.

In vain did he try, for the re-eftablifhment of his health, all the remedies which medicine, enlightened by the

(A) Abauzit, Cramer, Lhuilier, J. Trembley, &c.

(B) Jalabert, A. Trembley, Bonnet, Lefage, Deluc, Senebier, Prévoft, Pictet, and De Sauffure himfelf.

the physical sciences, could afford—all assistance was useless. The vital power quitted him with slow and painful steps. Towards the beginning of autumn 1798 his decay became more visible, his mind lost all its activity, and on the 22d of March 1799 he terminated his brilliant career, at the age of 59, lamented by a family to whom he was dear—by a country to which he had done honour—and by Europe, the knowledge of which he had extended.

SCALE, in architecture and geography, a line divided into equal parts, placed at the bottom of a map or draught, to serve as a common measure to all the parts of the building, or all the distances and places of the map.

SCALES, in mathematics, see SCALES (*Encycl.*), and likewise *Logarithmic Lines*, under which title are mentioned some improvements by Mr Nicholson on Gunter's scale. These improvements are valuable; and the reader will find a fuller account of them in the first volume of the author's *Philosophical Journal*.

SCANTLING, a measure, size, or standard, by which the dimensions, &c. of things are to be determined. The term is particularly applied to the dimensions of any piece of timber, with regard to its breadth and thickness.

SCAPEMENT, in clock-work, a general term for the manner of communicating the impulse of the wheels to the pendulum. The ordinary scapements consist of the swing-wheel and pallets only; but modern improvements have added other levers or detents, chiefly for the purposes of diminishing friction, or for detaching the pendulum from the pressure of the wheels during part of the time of its vibration. See WATCH Making, in this *Suppl.*

SCARFING, a term in carpentry; by which is meant the joining of two beams of wood together to increase the length: the beams in the joint are indented into one another, as in figures 19, 24, and 25, Plate X. *Supplement.*

SCARLET, a beautiful bright red colour given to cloth, either by a preparation of kermes (See that article in *Suppl.*), or more completely by the American cochineal. Professor Beckmann, in the second volume of his History of Inventions, seems to have established the following conclusions:

1*st*, Scarlet, or the kermes-dye, was known in the East in the earliest ages, before Moses, and was a discovery of the Phoenicians in Palestine, but certainly not of the small wandering Hebrew tribes. 2*d*, *Tola* was the ancient Phoenician name used by the Hebrews, and even by the Syrians; for it is employed by the Syrian translator, Isaiah, chap. i. ver. 18. Among the Jews, after their captivity, the Aramæan word *zehori* was more common. 3*d*, This dye was known also to the Egyptians in the time of Moses; for the Israelites must have carried it along with them from Egypt. 4*th*, The Arabs received the name kermes, with the dye, from Armenia and Persia, where it was indigenous, and had been long known; and that name banished the old name in the East, as the name scarlet has in the West. For the first part of this assertion we must believe the Arabs. 5*th*, Kermes were perhaps not known in Arabia; at least they were not indigenous, as the Arabs appear to have had no name for them. 6*th*, Kermes signifies always *red dye*; and when pronounced short, it becomes *deep red*. Scarlet.

Concerning the origin of the name scarlet, which was in use so early as the 11th century, our author has many conjectures, which we need not transcribe, as he seems not quite satisfied with any of them himself. The following reflections upon the comparative excellence of the ancient and modern scarlet, together with the progress of the art of dyeing that colour, are worthy of notice:

"Of the preparation and goodness of the ancient scarlet we certainly know nothing: but as we find in many old pieces of tapestry of the 11th century, and perhaps earlier, a red which has continued remarkably beautiful even to the present time, it cannot at any rate be denied, that our ancestors extolled their scarlet not without reason. We can, however, venture to assert, that the scarlet prepared at present is far superior, owing principally to the effects of a solution of tin.—This invention may be reckoned amongst the most important improvements of the art of dyeing, and deserves a particular relation.

"The tincture of cochineal alone yields a purple colour, not very pleasant, which may be heightened to the most beautiful scarlet by a solution of tin in aqua-regia (nitro-muriatic acid). This discovery was made as follows: [illegible]nelius Drebbel, who was born at Alkmaar, and died at London in [illegible], having placed in his window an [illegible] of cochineal, made with boiling water, for the [illegible] some aqua-regia d[illegible] cident, which [illegible] purple dye into a most beautiful [illegible] conjectures [illegible] which the [illegible] been dissolved [illegible] of this, changes [illegible] Kuffelar, [illegible] afterwards his [illegible] discovery to perfection, and [illegible] years alone in his dye-house, which gave [illegible] the name of Kuffelar's colour. In the course of time the secret became known [illegible] inhabitant of [illegible] called Gulich, and also to [illegible] a person of the name of Van der Vecht, who t[illegible] to the brothers Gobelins in France. Giles Gobelin, a dyer at Paris, in the time of Francis I. had found out an improvement of the then usual scarlet dye; and as he had remarked that the water of the rivulet Bievre, in the suburbs St Marceau, was excellent for his art, he erected on it a large dye-house; which, out of ridicule, was called *Folie Gobelins*, Gobelin's Folly. About this period, a Flemish painter, whom some name Peter Koek, and others Kloek, and who had travelled a long time in the East, established, and continued to his death in 1650, a manufactory for dyeing scarlet cloth by an improved method. Through the means of Colbert, one of the Gobelins learned the process used for preparing the German scarlet dye from one Gluck, whom some consider as the above-mentioned Gulich, and others as Kloek; and the Parisian scarlet dye soon rose into so great repute, that the populace imagined that Gobelin had acquired his art from the devil. It is well known that Louis XIV. by the advice of Colbert, purchased Gobelin's building from his

Scheme ‖ Scolymus.

his successors in the year 1667, and transformed it into a palace, to which he gave the name of *Hôtel royal des Gobelins*, and which he assigned for the use of first-rate artists, particularly painters, jewellers, weavers of tapestry, and others. After that time the rivulet was no longer called Bievre, but Gobelins. About the year 1643, a Fleming, named Kepler, established the first dye-house for scarlet in England, at the village of Bow, not far from London; and on that account the colour was called, at first, by the English, the *Bow dye*. In the year 1667, another Fleming, named Brewer, invited to England by King Charles II. with the promise of a large salary, brought this art there to great perfection."

SCHEME, a draught or representation of any geometrical or astronomical figure, or problem, by lines sensible to the eye; or of the celestial bodies in their proper places for any moment; otherwise called a diagram.

SCIAGRAPHY, or SCIOGRAPHY, the profile or vertical section of a building; used to shew the inside of it.

SCIAGRAPHY, in astronomy, &c. is a [illegible] used by some authors for the art of finding the hour [illegible] or night, by the shadow of the sun, moon, stars [illegible].

SCIOPTIC, or *Sciopteric Ball*, a sphere or [illegible] wood, with a circular hole or perforation, where a lens is placed. [illegible] it may be [illegible] way, to be used in experiments of the darkened room.

SCOLYMUS [illegible] by Pliny and [illegible] genus of [illegible] others of [illegible] sort of wool [illegible] leaves, [illegible] when [illegible] summer [illegible] milky juice. It was eaten both raw and cooked; and Theophrastus observes, as something very remarkable, that when the plant was in flower, or, as others explain the words, when it had finished blowing, it was most palatable. What renders this circumstance singular is, that most milky roots lose for food their milk, and become unfit to be eaten as soon as they have blown. This is the case with the goat's beard, which is eatable only the first year.

Professor Beckmann has, with much labour and erudition, endeavoured to ascertain what is really the plant which was known to the ancients by the name of *scolymus*. He seems to have proved sufficiently, that it was not the *cactus*, the *carduus*, or the *cinara*; but he has not been able to come to any other conclusion. "Were I appointed or condemned (says he) to form a new Latin dictionary, I should explain the article *scolymus* in the following manner: *Planta composita, capitata. Caulis longus, obsitus foliis spinosis. Radix carnosa, lactescens, nigra, dulcis, edulis. Calix squamis inermibus, disco carnoso, ante efflorescentiam eduli. Semina papposa. Turiones edules.* This description, short as it is, contains every thing that the ancients have said in order to characterise that plant."

Sconces, Scotales.

SCONCES, small forts, built for the defence of some pass, river, or other place. Some sconces are made regular, of four, five, or six bastions; others are of smaller dimensions, fit for passes or rivers; and others for the field.

SCOTALES, were meetings held formerly in England for the purpose of drinking ale, of which the expence was defrayed by joint contribution. Thus the tenants of South Malling in Sussex, which belonged [to] the Archbishop of Canterbury, were, at the keeping of a court, to entertain the Lord or his bailiff with a drinking, or an *ale*; and the stated quotas towards the charge were, that a man should pay three pence halfpenny for himself and his wife, and a widow and a cottager three halfpence. In the manor of Ferring, in the same county, and under the same jurisdiction, it was the custom for the tenants named to make a *scotale* of sixteen pence halfpenny, and to allow out of each sixpence three halfpence for the bailiff.

Common scotales in taverns, at which the clergy were not to be present, are noticed in several ecclesiastical canons. They were not to be published in the church by the clergy or the laity; and a meeting of more than ten persons of the same parish or vicinage was a scotale that was generally prohibited. There were also common drinkings, which were denominated *leet-ale, bride-ale, clerk-ale*, and *church-ale*. To a *leet-ale* probably all the residents in a manorial district were contributors; and the expence of a *bride-ale* was defrayed by the relations and friends of a happy pair, who were not in circumstances to bear the charges of a wedding dinner. This custom prevails occasionally in some districts of Scotland even at this day, under the denomination of a *penny bride-ale*, and was very common fifty or sixty years ago. The *clerk's* ale was in the Easter holidays, and was the method taken to enable clerks of parishes to collect more readily their dues.

Mr Warton, in his History of English Poetry, has inserted the following extract from an old indenture, which shews clearly the design of a *church-ale*. "The parishioners of Elveston and Okebrook, in Derbyshire, agree jointly to brew four ales, and every ale of one quarter of malt, betwixt this and the feast of St John the Baptist next coming; and that every inhabitant of the said town of Okebrook shall be at the several ales. And every husband and his wife shall pay two pence, every cottager one penny; and all the inhabitants of Elveston shall have and receive all the profits and advantages coming of the said ales, to *the use and behoof of the said church of Elveston*."

The *give-ales* were the legacies of individuals; and from that circumstance entirely gratuitous. They seem to have been very numerous, and were generally left to the poor; though, from the largeness of the quantity of ale enjoined to be brewed, it must have been sometimes intended that others were to partake of them. These bequests were likewise, not unfrequently, made to the light or altar of a saint, with directions for singing masses at the obit, trenthal, or anniversary of the testator. Hence, though scotales were generally kept in houses of public resort, the give-ales were sometimes dispensed in the church, and often in the churchyard; by which means "Godde's house (as Sumner says in his Treatise on Gavelkind) was made a tavern of gluttons." Such certainly would be Chalk church, if in it

was

Scowring. was kept the give-ale of William May of that parish; for he ordered his wife to "make in bread six bushels of wheat, and in drink ten bushels of mault, and in cheese twenty pence, to give to poor people for the health of his soull; and he ordered that, after the decease of his wife, his executors and feoffees should continue the custom for evermore."

SCOWRING OF STUFFS, is an art much more generally practised than understood It supposes, says Chaptal. 1st, a knowledge of the different substances capable of staining any kind of cloth; 2d, of the substances to which recourse must be had, in order to make those deposited on the stuff to disappear; 3d, a knowledge of the effects produced on colours by those reagents, which it may be necessary to employ to destroy stains; 4th, a knowledge of the manner in which the cloth is affected by those re agents; 5th, of the art of restoring a colour changed or faded. Of those bodies which occasion spots on different kinds of cloth, some are easily distinguished by their appearance, such as greasy substances; but others have more complex effects, such as acids, alkalies, perspired matter, fruits, urine, &c. Acids redden black, fawn, violet, and puce-colour, and every shade communicated with orchilla-weed, iron, astringents, and every blue except indigo and prussian blue. They render the yellows paler, except that of arnatto, which they change into orange.

Alkalies change to violet the reds produced by Brazil-wood, logwood, and cochineal. They render the greens on woollen cloth yellowish, make yellow brownish, and change the yellow produced by arnatto to aurora. P[illegible] matter produces the same effects as alkalies.

When the spots are produced by simple bodies on stuffs, it is easy to remove them by the means already known. Greasy substances are removed by alkalies, soaps, the yolk of eggs, fat earths; oxyds of iron, by the nitric and oxalic acids; acids by alkalies, and reciprocally. Stains of fruit on white stuffs may be removed by the sulphureous acid, and still better by the oxygenated muriatic acid. But when the spots are of a complex kind, it will be necessary to employ several means in succession. Thus, to destroy the stain of coom from carriage-wheels, after the grease has been dissolved, the oxyd of iron may be removed by the oxalic acid.

As colours are often changed by re-agents, it will be necessary, in order to restore them, that the scowrer should possess a thorough knowledge of the art of dyeing, and how to modify the means according to circumstances. This becomes the more difficult, when it is necessary to reproduce a colour similar to that of the rest of the stuff, to apply that colour only in one place, and often to restore the mordant by which it was fixed, and which has been destroyed, or even the first tint which gave the colour its intensity. It may be readily conceived, that the means to be employed must depend on the nature of the colour and the ingredients by which it was produced; for it is known that the same colour may be obtained from very different bodies. Thus, after an alkali has been employed to destroy an acid spot on browns, violets, blues, poppies, &c. the yellow spot which remains may be made to disappear by a solution of tin; a solution of sulphat of iron restores the colour to brown stuffs which have been galled; acids restore to their former splendour yellows which have been rendered dusky or brown by alkalies; blacks produced by logwood become red by acids; alkalies change these red spots to yellow, and a little of the astringent principle makes them again become black. A solution of one part of indigo in four parts of sulphuric acid, diluted with a sufficient quantity of water, may be employed with success to revive the blue colour of cotton or wool which has been changed. Scarlet may be revived by means of cochineal and a solution of the muriat of tin, &c.

The choice of re-agents is not a matter of indifference. Vegetable acids are preferable; the sulphureous acid, however, may be employed for stains occasioned by fruit; it does not change the blue of silk nor colours produced by astringents; it does not degrade the yellow of cotton. Ammonia succeeds better than fixed alkalies in removing spots produced by acids. It is employed in vapour; its action is speedy, and seldom alters the colour.

The means of removing greasy spots are well known. This effect is produced by alkalies, fullers earth, volatile oils dissolved in alcohol, a heat proper for volatilizing grease, &c. Spots occasioned by ink, rust, or iron-mould of any kind, and all those produced by the yellow oxyd of iron, are removed by the oxalic acid: the colour may be restored by alkalies, or a solution of the muriat of tin. These spots may be removed also by the oxygenated muriatic acid, when they are on white stuffs or paper.

The acid [illegible] alka[illegible] matter, are the [illegible] acids, or even by a weak solu[illegible] When these spots arise from [illegible] in order to destroy [illegible] polychrest composition [illegible] one of the most [illegible] and mix [illegible] with [illegible] four to six eggs; add gradually essence of [illegible] corporate with the whole some [illegible] in such a manner as to form balls of a [illegible] consistence. Moisten the spot; and having rubbed it with these balls, the spot will be removed by washing the stuff. All spots, except iron-mould and ink, may be removed in this manner.

Washing destroys the lustre, and [illegible] a tarnished place disagreeable to the eye; but the lustre may be restored by drawing over the washed place, and in the direction of the pile, a brush moistened in water, impregnated with a little gum. You may then apply a sheet of paper, or a piece of cloth, and a considerable weight, under which the cloth must be left to dry.

Scowring, Scylla.

SCYLLA. Under this title we gave, in the *Encyclopædia*, an account of Scylla and Charybdis, which, though taken from a work which we thought good authority, appears to be far from correct. These places, so famous in the poems of Homer and Virgil, were examined with minute attention by that accurate observer of nature the Abbé Spallanzani; who thus describes Scylla.

"It is a lofty rock, distant twelve miles from Messina, which rises almost perpendicularly from the sea on the shore of Calabria, and beyond which is the small city of the same name. Though there was scarcely any wind, I began to hear, two miles before I came to the rock,

rock, a murmur and noise like a confused barking of dogs, and on a nearer approach readily discovered the cause. This rock, in its lower parts, contains a number of caverns, one of the largest of which is called by the people there *Dragara*. The waves, when in the least agitated, rushing into these caverns, break, dash, throw up frothy bubbles, and thus occasion these various and multiplied sounds. I then perceived with how much truth and resemblance of nature Homer and Virgil, in their personifications of Scylla, had pourtrayed this scene, by describing the monster they drew as lurking in the darkness of a vast cavern, surrounded by ravenous barking mastiffs, together with wolves, to increase the horror.

"Such is the situation and appearance of Scylla: let us now consider the danger it occasions to mariners. Though the tide is almost imperceptible in the open parts of the Mediterranean, it is very strong in the strait of Messina, in consequence of the narrowness of the channel, and is regulated, as in other places, by the periodical elevations and depression of the water. Where the flow or current is accompanied by a wind blowing the same way, vessels have nothing to fear, since they either do not enter the strait, both the wind and the stream opposing them, but cast anchor at the entrance; or, if both are favourable, enter on full sail, and pass through with such rapidity that they seem to fly over the water. But when the current runs from south to north, and the north wind blows hard at the same time, the ship which [illegible] to [illegible] the strait with the wind in its [illegible] as resisted by the [illegible] and, [illegible] by two forces in contrary directions, is at length dashed on the rock of Scylla, [illegible] the neighbouring sands; unless the [illegible] necessary for his preservation. [illegible] in case of such accidents, 24 of the strongest [illegible] and most experienced sailors, well acquainted with the place, are stationed night and day along the shore of [illegible]; who, at the report of guns fired as signals of distress from any vessel, hasten to its assistance, and tow it with one of their light boats. The current, where it is strongest, does not extend over the whole strait, but winds thro' it in intricate meanders, with the course of which these men are perfectly acquainted, and are thus able to guide the ship in such a manner as to avoid it. Should the pilot, however, confiding in his own skill, contemn or neglect this assista[illegible] his ability or experience, he would run the most imminent risk of being shipwrecked. In this agitation and conflict of the waters, forced one way by the current, and driven in a contrary direction by the wind, it is useless to throw the line to discover the depth of the bottom, the violence of the current frequently carrying the lead almost on the surface of the water. The strongest cables, though some feet in circumference, break like small cords. Should two or three anchors be thrown out, the bottom is so rocky that they either take no hold; or, if they should, are soon loosened by the violence of the waves. Every expedient afforded by the art of navigation, though it might succeed in saving a ship in other parts of the Mediterranean, or even the tremendous ocean, is useless here. The only means of avoiding being dashed against the rocks, or driven upon the sands in the midst of this furious contest of the winds and waves, is to have recourse to the skill and courage of these Messinese seamen."

Scylla.

Charybdis is situated within the strait, in that part of the sea which lies between a projection of land named *Punta Secca*, and another projection on which stands the tower called *Lanterna*, or the light-house, a light being placed at its top to guide vessels which may enter the harbour by night. Every writer, who has hitherto described Charybdis, has supposed it to be a whirlpool; but this is a mistake, as Spallanzani has completely proved, by ascertaining what it really is.

"Charybdis is distant from the shore of Messina about 750 feet, and is called by the people of the country *Calofaro*, not from the agitation of the waves, as some have supposed, but from καλος and φαρος; that is, *the beautiful tower*, from the light-house erected near it for the guidance of vessels. The phenomenon of the Calofaro is observable when the current is descending; for when the current sets in from the north, the pilots call it the *descending rema*, or current; and when it runs from the south, the *ascending rema*. The current ascends or descends at the rising or setting of the moon, and continues for six hours. In the interval between each ascent or descent, there is a calm which lasts at least a quarter of an hour, but not longer than an hour. Afterwards, at the rising or setting of the moon, the current enters from the north, making various angles of incidence with the shore, and at length reaches the Calofaro. This delay sometimes continues two hours; sometimes it immediately falls into the Calofaro; and then experience has taught that it is a certain token of bad weather."

When our author observed Charybdis from the shore, it appeared like a group of tumultuous waters; which group, as he approached, became more extensive and more agitated. He was carried to the edge, where he stopped some time to make the requisite observations; and was then convinced, beyond the shadow of a doubt, that what he saw was by no means a vortex or whirlpool.

Hydrologists teach us, that by a whirlpool in a running water we are to understand that circular course which it takes in certain circumstances; and that this course or revolution generates in the middle a hollow inverted cone, of a greater or less depth, the internal sides of which have a spiral motion. But Spallanzani perceived nothing of this kind in the Calofaro. Its revolving motion was circumscribed to a circle of at most 100 feet in diameter; within which limits there was no incurvation of any kind, nor vertiginous motion, but an incessant undulation of agitated waters, which rose, fell, beat, and dashed on each other. Yet these irregular motions were so far placid, that nothing was to be feared in passing over the spot, which he did; though their little bark rocked very much from the continual agitation, so that they were obliged constantly to make use of their oars to prevent its being driven out of the Calofaro. Our author threw substances of different kinds into the stream. Such as were specifically heavier than the water sunk, and appeared no more; those which were lighter remained on the surface, but were soon driven out of the revolving circle by the agitation of the water.

Though from these observations he was convinced that there was no gulph under the Calofaro, as otherwise

Scylla, Sea-sickness.

wise there would have been a whirlpool, which would have carried down into it the floating substances; he determined to sound the bottom with the plummet, and found its greatest depth did not exceed 500 feet. He was likewise informed, to his no small surprise, that beyond the Calofaro, towards the middle of the strait, the depth was double.

When the current and the wind are contrary to each other, and both in their greatest violence, especially when the scilocco, or south wind, blows, the swelling and dashing of the waves within the Calofaro is much stronger, more impetuous, and more extensive. It then contains three or four small whirlpools, or even more, according to the greatness of its extent and violence. If at this time small vessels are driven into the Calofaro by the current or the wind, they are seen to whirl round, rock, and plunge, but are never drawn down into the vortex. They only sink when filled with water, by the waves beating over them. When vessels of a larger size are forced into it, whatever wind they have they cannot extricate themselves; their sails are useless; and after having been for some time tossed about by the waves, if they are not assisted by the pilots of the country, who know how to bring them out of the course of the current, they are furiously driven upon the neighbouring shore of the Lanterna, where they are wrecked, and the greater part of their crews perish in the waves.

From these facts, the classical reader will perceive, that the ancient descriptions of Charybdis are by no means so accurate as those of Scylla. The saying, however, which became proverbial among the ancients, viz. that "he who endeavours to avoid Charybdis, dashes upon Scylla," is, in a great measure, true. If a ship be extricated from the fury of Charybdis, and carried by a strong southerly wind along the strait towards the northern entrance, it will indeed pass out safely; but should it meet with a wind in a nearly opposite direction, it would become the sport of both these winds, and, unable to advance or recede, be driven in a middle course between their two directions, that is to say, full upon the rock of Scylla, if it be not immediately assisted by the pilots. It is likewise observed, that in these hurricanes a land wind frequently rises, which descends from a narrow pass in Calabria, and increases the force with which the ship is impelled towards the rock.

SEA-SICKNESS is a disorder which has been but little treated of, notwithstanding the frequency of its occurrence, and the irksomeness and distress to which the patient is subjected during its continuance. It has been found to be very beneficial in several diseases, among which the principal are asthmatic and pulmonary complaints; and there are very few instances of its being attended with fatal consequences. The sea-sickness seems to be a spasmodic affection of the stomach, produced by the alternate pressure and recess of the contents of that viscus against its lower internal surface, according as the rise and fall of the ship opposes or recedes from the action of gravity.

The seas in which this disorder attacks the passenger with the greatest violence, are those where the waves have long uninterrupted freedom of action; of course, bays, gulphs, and channels, may be navigated with less inconvenience, as the waves, meeting with more frequent resistance, and the repercussion being considerably stronger, the vessel does not experience that gentle uniform vacillation which sickens the stomach, and renders the head giddy. By the same argument, a person feels less inconvenience from the disorder on the wide ocean in a small vessel, on which the slightest motion of the waves makes a strong impression. He is likewise less exposed to it in a very large vessel, as in a ship of the line, or a large merchantman deeply laden; as the waves, in this case, scarcely affect the vessel. It is in ships of the middling size, and which carry but a light cargo, that the passenger suffers most from the sea sickness. It has been observed, that this disorder affects people in years less than young persons; those of a dark less than those of a fair complection, and that it seldom attacks infants. The duration is not limited to any fixed period of time; with some it lasts only a few days, with others weeks, months, and even during the whole course of the voyage. The sooner it takes place after embarkation, the greater probability is there of its continuance. It does not always cease immediately on landing, but has been known, in some cases, to continue for a considerable time. Even the oldest and most skilful seamen have experienced a relapse, especially if they have quitted the sea service for a long term of years.

There have been ma[illegible] recommended for mitigating, if not entirely [illegible]g, this disorder; among which the following seem the [illegible] effic[illegible]

1. Not to go on board [illegible] eating; and, w[illegible] to eat in any great quantity at any [illegible] e meal.

2. To [illegible] as conveniently [illegible] at the pumps, [illegible] indolent and slothful passengers [illegible] from the disorder.

3. To keep much upon deck, even in stormy and rainy weather, as the sea breeze is less liable to affect the stomach than the fluctuated air of the cabin, which is frequently rendered infectious for want of sufficient circulation.

4. Not to watch the motion of the waves, especially when strongly agita[illegible] with tempest.

5. To avoid carefully all employment which harass the mind, as reading, study, meditation, and gaming; and, on the other hand, to seek every opportunity of mirth and mental relaxation.

6. To drink occasionally carbonic acids, as the froth of strong fermented beer, or wine mixed with Seltzer water, and fermented with pounded sugar, or a glass of Champaign.

7. It will be found of great service to take the acid of sulphur dulcified, dropped upon lump sugar, or in peppermint-water; or ten drops of sulphureous ether.

With regard to eating, it is advisable to be very sparing, at least not to eat much at one meal. The proper diet is bread and fresh meat, which should be eaten cold with pepper. All sweet favoured food should be carefully avoided; and the passenger should refrain from fat, but especially from all meat that is in the least degree tainted. Even the odour of flowers is very pernicious; for which reason, it is not expedient to examine marine productions, as these generally have a nauseating smell. The fumes of vinegar may be inhaled with great benefit. The drink should consist of

tart wines, lemonade, or Seltzer water, but never of common water. The passenger would do well to drink little and often. As experience has proved, that an accidental diarrhœa has frequently relieved the patient from the sea-sickness, it will be prudent to follow the clue of nature, and take a gentle laxative, or, if circumstances will permit, a clyster of salt water and Venice soap, which is the more necessary, as sea-faring people are liable to obstructions. It will further be found useful to apply to the pit of the stomach a tonic anodyne antispasmodic emplastrum, spread upon leather, and covered with linen.

Where the above preventives have not been employed, or have not succeeded in securing the passenger from the sea-sickness, he may, however, experience considerable relief from the following remedies:

If symptoms of vomiting appear, they may frequently be remedied by the patient prostrating himself in a horizontal position, upon the back or belly, and lying perfectly still. We would recommend likewise a gentle compression of the abdomen. But if the fits of vomiting are too violent to be repressed, in that case, it is best to promote them by a strong dose of salt-water; an expedient, however, which must not be too often repeated, as it [illegible] more to weaken the stomach. When the emetic takes effect, let the patient bend his body, advancing his knees towards his breast, and support his head against a firm [illegible] resting place. He must be particularly careful [illegible] his garters and cravat, as this precaution will secure him from the risk of a rupture, and from the ill effects of the blood rushing violently towards the head and breast.

After the [illegible] has subsided, its return may be [illegible] of repose, and even [illegible] time. Let the patient choose a cool [illegible] remembering to keep himself warm and well covered, as perspiration is highly salutary. But he must not indulge in too long sleep during the day-time, as this induces torpidness. In the morning he should constantly take a gargle of sugar dissolved in vinegar. Let him eat often, but sparingly; and if he can content himself with a dish of chocolate, coffee, or strong tea, he will reap still greater benefit. He should never drink water in its pure elementary state, but mix it with brandy, vinegar, or wine. In the morning, instead of brandy, he may take a glass of wine, with an infusion of orange peel, gentian root, or peruvian bark (*quinquina*). A glass of punch taken occasionally will prove of very essential service, as it promotes perspiration.

Persons in the habit of smoking, will find a pleasant and salutary companion in the pipe; but those who are not accustomed to it will be sufferers by taking to the practice.

In conclusion, it is proper to add, that warm clothing, flannel shirts, trowsers, caps, &c. are efficacious remedies against excessive expectoration, and all other symptoms of this terrible disorder.

SECTOR of a Sphere, is the solid generated by the revolution of the sector of a circle about one of its radii; the other radius describing the surface of a cone, and the circular arc a circular portion of the surface of the sphere of the same radius. So that the spherical sector consists of a right cone, and of a segment of the sphere having the same common base with the cone. And hence the solid content of it will be found by multiplying the base or spherical surface by the radius of the sphere, and taking a third part of the product.

Sector of an ellipse, or *of an hyperbola*, &c. is a part resembling the circular sector, being contained by three lines, two of which are radii, or lines drawn from the centre of the figure to the curve, and the intercepted arc or part of that curve.

SEEDS, Preservation of, in a state fit for vegetation, is a matter of great and general importance, because, if it can be accomplished, it will enable us to rear many useful plants in one country which are there unknown, being indigenous only in others at a great distance from it. There is a letter on this subject in the 16th volume of the *Transactions of the Society of Arts*, &c. from which we shall extract what is fit for our purpose.

"Many years ago (says the author), having observed some seeds which had got accidentally amongst raisins, and that they were such as are generally att[illegible]ed difficulty to raise in England after coming in the way from abroad, I sowed them in pots, within ming; and as all of them grew, I commissi[illegible] sons, who were then abroad, to pack up all [illegible] seeds they could procure in absorbent paper, some of them surrounded by raisins, and others brown moist sugar; concluding that the former seeds had been preserved by a peculiarly favourable state of moisture thus afforded them. It occurred, likewise, that as many of our common seeds, such as clover, charlock, &c. would lie dormant for ages with[illegible] the earth, well preserved for vegetation whenever they might happen to be thrown to the surface, and exposed to the atmosphere, so these foreign seeds might be equally preserved, for many months at least, by the kindly covering and genial moisture that either raisins or sugar afforded them: and this conjecture was really fulfilled, as not one in twenty of them failed to vegetate, when those of the same kinds, that I ordered to be sent lapped in common parcels, and forwarded with them, would not grow at all. I observed, upon examining them all before they were committed to the earth, that there was a prevailing dryness in the latter, and that the former looked fresh and healthy, and were not in the least infested by insects, as was the case with the others. It has been tried repeatedly to convey seeds (of many plants difficult to raise) closed up in bottles, but without success; some greater proportion of air, as well as a proper state of moisture, perhaps, being necessary. I should also observe, that no difference was made in the package of the seeds, respecting their being kept in husks, pods, &c. so as to give those in raisins or sugar any advantage over the others, all being sent equally guarded by their natural teguments."

SEGALIEN, the name given by Europeans to a large island separated by a narrow channel from the coast of Chinese Tartary, and called by the natives *Tchoka*, and by the Chinese *Oku-Jesso*. It lies between the 46th and 54th degrees of north latitude, but its breadth from east to west is not known. Indeed hardly any thing about it was known till the year 1787, that M. La Perouse penetrated almost to the bottom of the channel which separates it from the continent, and which grew so very shallow as he advanced northward

that,

Segalien. that, in all probability, the island will soon become a peninsula. The French frigates came to anchor in different bays on the coast of Segalien; and the finest of these bays, to which the Commodore gave the name of *Baie d'Estaing*, is situated in 48° 59′ N. Lat. and 140° 32′ Lon. East from Paris.

La Perouse and M. Rollin, the surgeon of his ship, both describe the natives of this island as a worthy and intelligent people. Of the presents which were made to them, they seemed to set a value only on such as were useful. Iron and stuffs prevailed over every thing; they understood metals as well as their guests, and for ornament preferred silver to copper, and copper to iron. They make use of looms, which, though small, are very complete instruments; and by means of spindles they prepare thread of the hair of animals, of the bark of the willow, and the great nettle, from which they make their stuffs. They are of a moderate size, squat, and strong built, with the muscles of their bodies very exactly defined: their common height is five feet, and the greatest does not exceed five feet four inches; but men of this size are very uncommon among them. They have all a large head, and a broader and more rounded face than Europeans; their countenance is animated and agreeable, though, upon the whole, it is destitute of that regularity and grace which we esteem so essential to beauty: they have large cheeks, a short nose rounded at its extremity, with very broad nostrils: their eyes are lively, of a moderate size, for the most part black, though some have blue ones among them: their eyebrows are bushy, their mouth of the common size, their voice is strong, their lips are rather thick, and of a dull red: M. Rollin remarked, that in several the upper lip was tattoed, and tinged of a blue colour: these, as well as their eyes, are capable of every variety of expression: their teeth are white, even, and of the usual number; their chin is rounded and a little advancing: their ears are small: they bore and wear in them glass ornaments or silver rings.

The women are not so large as the men, and are of a more rounded and delicate figure, though there is but little difference between the features of their faces. Their upper lip is tattoed all over of a blue colour, and they wear their hair long and flowing: their dress hardly differs from that of the men; the colour of the skin in both sexes is tawny, and that of their nails, which they suffer to grow to a great length, is a shade darker than that of Europeans. These islanders are very hairy, and have long beards, which gives, especially to the old men, a grave and venerable air: these last appear to be held in much respect by the younger part of the inhabitants. The hair of their head is black, smooth, and moderately strong; in some it is of a chesnut colour: they all wear it round, about six inches long behind, and cut into a brush on the top of their head and over the temples.

Their clothing consists of a kind of surtout which wraps over before, where it is fastened by little buttons, strings, and a girdle placed above the haunches. This surtout is made of skin or quilted nankeen, a kind of stuff that they make of willow bark: it generally reaches to the calf of the leg, and sometimes even lower, which for the most part renders the use of drawers unnecessary: some of them wear seal skin boots, the feet of which, in form and workmanship, resembles the Chinese shoe but the greater number of them go bare-footed and bare-headed: a few indeed wear a bandage of bear-skin round the head; but this is rather as an ornament than a defence against the weather. Segalien.

Like the lower classes of the Chinese, they all wear a girdle, to which they hang their knife as a defence against the bears, and several little pockets, into which they put their flint and steel, their pipe, and their box of tobacco; for they make a general practice of smoking.

Their huts are sufficient to defend them against the rain and other inclemencies of the air, but are very small in proportion to the number of the inhabitants which they contain. The roof is formed of two inclined planes, which are from ten to twelve feet high at their junction, and three or four on the sides: the breadth of the roof is about fifteen feet, and its length eighteen: these cabins are constructed of frame work, strongly put together, the sides being filled up with the bark of trees, and the top thatched with dry grass in the same manner as our cottages are.

On the inside of these houses is a square of earth raised about six inches above the ground, and supported on the sides by strong planking; on this they make the fire: along the sides of the apartment are benches twelve or fifteen inches high, which they cover with mats, on which they sleep.

The utensils that they employ in cooking their food consist of an iron pot, shells, vessels made of wood and birch bark, of various shapes and workmanship; and, like the Chinese, they take up their food with little sticks: they have generally two meals in the day, one at noon, and the other in the evening.

The habitations in the south part of the island are much better built and furnished, having for the most part planked floors: our author saw in them some vessels of Japan porcelain, on which the owners appeared to set great value, probably because they are not to be procured but with great trouble and at considerable expence. They cultivate no kind of vegetable, living only on dried and smoked fish, and what little game they take by hunting.

Each family has its own canoe, and implements for fishing and hunting. Their arms are bows, javelins, and a kind of spontoon, which they use principally in bear-hunting. By the side of their houses are the magazines, in which they lay up the provision which they have prepared and collected during summer for their winter subsistence. It consists of dried fish, and a considerable quantity of garlic and wild celery, angelica, a bulbous root which they call *apé*, better known under the name of the yellow lily of Kamtschatka, and fish oil, which they preserve in the stomachs of bears, and other large animals. These magazines are made of planks, strongly and closely put together, raised above the ground on stakes about four feet high.

Dogs are the only domestic animals belonging to the natives of Tchoka; they are of a middling size, with shaggy hair, pricked ears, and a sharp long muzzle; their cry is loud and not savage.

These people, who are of a very mild and unsuspecting disposition, appear to have commercial intercourse with the Chinese by means of the Mantchou Tartars, with the Russians to the north of their island, and the Japanese to the south: but the articles of trade are of

no

no great consequence, consisting only of a few furs and whale oil. This fish is caught only on the southern coast of the island. Their mode of extracting the oil is by no means economical; they drag the whale on shore on a sloping ground, and suffering it to putrify, receive in a trench, at the foot of the slope, the oil, which separates spontaneously.

The island is well wooded, and mountainous towards the centre, but is flat and level along the coast, the soil of which appears admirably adapted to agriculture: vegetation is extremely vigorous here; forests of pine, willow, oak, and birch, cover nearly the whole surface. The sea abounds with fish, as well as the rivers and brooks, which swarm with salmon and trout of an excellent quality. The weather is, in general, foggy and mild. All the inhabitants have an air of health and strength, which they retain even to extreme old age; nor did our author observe among them any instance of defective organization, or the least trace of contagious or eruptive disorders.

SEGMENTS, LINE OF, are two particular lines, so called on Gunter's sector. They lie between the lines of sines and superficies, and are numbered with 5, 6, 7, 8, 9, 10. They represent the diameter of a circle, so divided into 100 parts, as that a right line drawn through those parts, and perpendicular to the diameter, shall cut the circle into two segments, the greater of which shall have [illegible] to the whole circle, as the parts on [illegible] to 100.

SEGO, the [illegible] of the kin[illegible] of Bambarra in Africa, is [illegible] banks of the Niger, in 14° 4' N[illegible] It consists, properly s[illegible] two on the northern [illegible], and Sego Boo; and [illegible] Sego Soo Korro, and [illegible] surrounded with high mud-walls; the houses are built of clay, of a square form, with flat roofs; some of them have two stories, and many of them are whitewashed. Besides these buildings, Moorish mosques are seen in every quarter; and the streets, though narrow, are broad enough for every useful purpose in a country where wheel carriages are entirely unknown. Mr Park informs us, that from the best inquiries that he could make, he has reason to believe that Sego contains altogether about thirty thousand inhabitants. The King of Bambarra constantly resides at Sego See Korro; he employs a great many slaves in conveying people over the river, and the money they receive (though the fare is only ten kowrie shells for each individual) furnishes a considerable revenue to the king in the course of a year. The canoes are of a singular construction, each of them being formed of the trunks of two large trees, rendered concave, and joined together, not side by side, but endwise; the junction being exactly across the middle of the canoe: they are therefore very long and disproportionably narrow, and have neither decks nor masts; they are, however, very roomy; for our author observed in one of them four horses, and several people, crossing over the river. The view of this extensive city; the numerous canoes upon the river; the crowded population, and the cultivated state of the surrounding country, formed altogether a prospect of civilization and magnificence which he little expected to find in the bosom of Africa.

He met not, however, in Sego with that hospitality which he had experienced in some other African towns. The Moors, who abound in it, and whose bigotry renders them the implacable enemies of every white man suspected of being a Christian, contrived to persuade the king that it was for no good purpose he had come into the territories of Bambarra. He was therefore ordered to take up his residence at a village a little distant, without being admitted into the royal presence. Even there, so strong was the prejudice that had been excited against him, no person would admit him into his house. About sunset, however, as he was preparing to pass the night in the top of a tree, that he might not be in danger of being torn to pieces by wild beasts, a poor Negro woman conducted him to her hut, dressed a fine fish for his supper, and furnished him with a mat to sleep on. She then called to the female part of her family, who had stood gazing on him all the while with fixed astonishment, to resume their task of spinning cotton; in which they continued to employ themselves great part of the night. They lightened their labour by songs; one of which was composed extempore, for our author was himself the subject of it. It was sung by one of the young women, the rest joining in a sort of chorus. The air was sweet and plaintive, and the words, literally translated, were these—"The winds roared, and the rains fell.—The poor white man, faint and weary, came and sat under our tree.—He has no mother to bring him milk; no wife to grind his corn. *Chorus*. Let us pity the white man; no mother has he", &c. &c. "Trifling (says Mr Park) as this recital may appear to the reader, to a person in my situation the circumstance was affecting in the highest degree."

Having remained three days in this village, he was dismissed on the fourth, after receiving from the king 5000 kowries, to enable him to purchase provisions in the course of his journey. Though this sum amounted only to one pound sterling, so cheap are the necessaries of life in Bambarra, that it was sufficient to purchase provisions for himself, and corn for his horse, for fifty days.

SELL, in building, is of two kinds, viz. *Ground Sell*, which denotes the lowest piece of timber in a wooden building, and that upon which the whole superstructure is raised; and *Sell of a Window*, or *of a Door*, which is the bottom piece in the frame of them, upon which they rest.

SENN, a kind of itinerant cowkeeper in Switzerland, particularly in the canton of Appenzell. These men do not grow so much hay themselves as they require for their cattle during the winter season, and some of them have no grass lands at all. To supply this deficiency, they employ agents throughout the canton, who are to inform them where good hay may be obtained, which farmers made it in favourable weather, &c. and then the Senn, or the great cowkeeper, who is in want of fodder, makes his agreements for the winter with the wealthier farmers, to whom he successively drives his cattle as soon as they return from grass. Thus the itinerant Senn, with his cows, often visits five different places during the winter season. He who sells the hay furnishes the Senn not only with stabling for his beasts, but boards and lodges him as well as his whole family. In return, the Senn, besides paying the stipulated price for the hay, allows to his host as much milk, whey, and *zieger* (a kind of lean cheese) as may be

Senn. be used in the house, and leaves him also the manure of his cows. In the middle of April, when Nature revives, the Senn again issues forth with his herd to the meadows and fertile Alps, which he rents for the summer. Thus the life of these men is a constant migration, affording the most pleasing variety, and blessing them with health, content, and cheerfulness; but they had not been then cursed with French fraternity.

Fine cattle are the pride of the cowkeeper who inhabits the Alps:—but, not satisfied with their natural beauty, he will likewise please his vanity. He adorns his best cows with large bells suspended from broad thongs; and the expence in such bells is carried even to a luxurious excess. Every Senn has an harmonious set of at least two or three bells, chiming in with the famous *ranz des vaches* (A). The inhabitants of the Tyrol bring a number of such bells, of all sizes, to every fair kept in the canton of Appenzell. They are fixed to a broad strap, neatly pinked, cut out, and embroidered; which is fastened round the cow's neck by means of a large buckle. A bell of the largest size measures upwards of a foot in diameter, is of an uniform width at top, swells out in the middle, and tapers towards the end. It costs from forty to fifty gilders; and the whole peal of bells, including the thongs, will sometimes be worth between 140 and 150 gilders, while the whole apparel of the Senn himself, when best attired, does not amount to the price of twenty gilders. The finest black cow is adorned with the largest bell, and those next in appearance have two smaller. These ornaments, however, are not worn on every day, but only on solemn occasions, viz. when, in the spring, they are driven up the Alps, or removed from one pasture to another; or when they descend in the autumn, or travel in the winter to the different farms, where their owner has contracted for hay. On such days, the Senn, even in the depth of winter, appears dressed in a fine white shirt, of which the sleeves are rolled up above the elbow; neatly embroidered red braces keep up his yellow linen trowsers, which reach down to the shoes; a small leather cap, or hat, covers his head; and a new milk bowl, of wood skilfully carved, hangs across the left shoulder. Thus arrayed, the Senn precedes singing the *ranz des vaches*, and followed by three or four fine goats; next comes the handsomest cow with the great bell; then the two other cows with smaller bells; and these are succeeded by the rest of the cattle walking one after another, and having in their rear the bull with a one-legged milking stool hanging on his horns; the procession is closed by a *traineau*, or sledge, on which are placed the implements for the dairy. It is surprising to see how proud and pleased the cows stalk forth when ornamented with their bells. Who would imagine that even these animals are sensible of their rank, nay, touched with vanity and jealousy? If the leading cow, who hitherto bore the largest bell, be deprived of her honours, she very plainly manifests her grief at the disgrace, by lowing incessantly, abstaining from food, and growing lean. The happy rival, on whom the distinguishing badge of superiority has devolved, experiences her marked vengeance, and is butted, wounded, and persecuted by her in the most furious manner; until the former either recovers her bell, or is entirely removed from the herd. However singular this phenomenon may appear, it is placed beyond all doubt by the concurring testimony of centuries.

Serrishtehdar || Shadows.

The cows, when dispersed on the Alps, are brought together by the voice of the Senn, who is then said to *allure* them (*locken*). How well the cattle distinguish the note of their keeper appears from the circumstance of their hastening to him, though at a great distance, whenever he begins to hum the *ranz des vaches*. He furnishes that cow which is wont to stray farthest with a small bell, and knows by her arrival that all the rest are assembled.

SERRISHTEHDAR, in Bengal, keeper of records or accounts.

SEVEN STARS, a common denomination given to the cluster of stars in the neck of the sign Taurus, the bull, properly called the *Pleiades*. They are so called from their number seven which appear to the naked eye, though some eyes can discover only six of them; but by the help of telescopes there appears to be a great multitude of them.

SEZAWUL, in Bengal, an officer deputed occasionally to enforce the due payment of the revenue.

SHADOWS (COLOURED), a curious [illegible] nomenon, which was observed a considerab[illegible] number of years ago, by Professor [illegible] of Vienna, and more lately by Count [illegible] the discovery wh[illegible] light [illegible] of which the read[illegible] under the titles LAMP and [illegible] in this *Suppl.* "De[illegible]strous (says he) of comparing the intensity of the light of a clear blue sky by day with that of a common wax candle, I darke[illegible] room, and letting the day-light from the north, coming thro' a hole near the top of the window-shutter, fall at an angle of about 70° upon a sheet of very fine white paper, I placed a [illegible] ax-candle in such a position that its rays [illegible] upon the same paper, and, as near as I could [illegible]s, in the line of reflection of the rays of day-light [illegible]; when, interposing a cylinder of wood, [illegible]alf an inch in diameter, before the centre of [illegible], and at the distance of about two inches from its surface, [illegible] much surprised to find that the two shadows p[illegible] by the cylinder upon the paper, instead of being merely shades without colour, as I expected; the one of them, that which, corresponding with the beam of day-light, was illuminated by the candle, was yellow; while the other, corresponding to the light of the candle, and consequently illuminated by the light of the heavens, was of the most beautiful blue that it is possible to imagine. This appearance, which was not only unexpected, but was really in itself in the highest degree striking and beautif[illegible].

(A) This famous pastoral song is never sung by the cowherds with words to it: all the tones of it are simple, and mostly formed within the throat. Hence the tune produces very little or no motion of the jawbones, and its sounds do not resemble those which commonly issue from the human throat, but rather seem to be the tones of some wind instrument; particularly as scarcely any breathing is perceived, and as the cowherds sometimes sing for minutes together without fetching breath.

beautiful, I found upon repeated trials, and after varying the experiment in every way I could think of, to [illegible] that it is absolutely impossible to produce two shadows at the same time, from the same body, the one answering to a beam of day light, and the other to the light of a candle or lamp, without these shadows being coloured, the one yellow, and the other blue.

"If the candle be brought nearer to the paper, the blue shadow will become of a deeper hue, and the yellow shadow will gradually grow fainter; but if it be removed farther off, the yellow shadow will become of a deeper colour, and the blue shadow will become fainter; and the candle remaining stationary in the same place, the same varieties in the strength of the tints of the coloured shadows may be produced merely by opening the window-shutter a little more or less, and rendering the illumination of the paper, by the light from without, stronger or weaker. By either of these means, the coloured shadows may be made to [illegible] through all [illegible] gradations of [illegible] des, from the deepest to the lightest [illegible] vice [illegible] and it is not a little amusing to see [illegible] shadow [illegible] lowing with all the brilliancy of the purest and most [illegible] colours, then passing suddenly through all the varieties of shade, preserving in all the most perfect purity of tint, growing stronger and fainter, and vanishing and returning at command."

With respect to the cause of the colours of these shadows, there is no doubt [illegible] but they arise from the different qualities of the light by which they are illuminated [illegible] they are produced, does not [illegible] de[illegible] philosopher, [illegible] shadows which [illegible] accounted for by Professor [illegible] Co[illegible]

SHAGREEN, or CHAGRIN, [illegible] a kind of grained leather [illegible] process of preparing which, we gave the best account that we could then find in the *Encyclopaedia*. That account, however, as we learn from Professor Pallas, is very defective. He says, indeed, that no accurate account of it has ever been published [illegible] his own, of which we shall now lay an [illegible] our readers.

"All kinds of horse or ass skin, which have been dressed in such a manner as to appear grained are, by the Tartars, called *saumer*, by the Persians *sogre*, and by the Turks *sagri*, from which the Europ[illegible] made *shagreen* or *chagrin*. The Tartars who reside at Astracan, with a few of the Armenians of that city, are the only people in the Russian empire acquainted [illegible] the art of making shagreen. Those who follow this occupation not only gain considerable profit by the sale of their production to the Tartars of Cuban, Astracan, and Casan, who ornament with it their Turkey leather boots, slippers, and other articles made of leather, but they derive considerable advantage from the great sale of horses hides, which have undergone no other process than that of being scraped clean, and of which several thousands are annually exported, at the rate of from 75 to 85 roubles per hundred, to Persia, where there is a scarcity of such hides, and from which the greater part of the shagreen manufactured in that country is prepared. The hind part only of the hide, however, which is cut out in the form of a crescent about a Russian ell and a half in length across the loins, and a short ell in breadth along the back, can properly be employed for shagreen. The remaining part, as is proved by experience, is improper for that purpose, and is therefore rejected.

"The preparation of the skins, after being cut into the above form, is as follows:—They are deposited in a tub filled with pure water, and suffered to remain there for several days, till they are thoroughly soaked, and the hair has dropped off. They are then taken from the tub, one by one, extended on boards, placed in an oblique direction against a wall, the corners of them, which reach beyond the edges of the board, being made fast, and the hair with the epidermis is then scraped off with a blunt iron scraper called *urak*. The skins thus cleaned are again put in pure water to soak. When all the skins have undergone this part of the process, they are taken from the water a second time, spread out one after the other as before, and the fleshy side is scraped with the same kind of instrument. They are carefully cleaned also on the hair side, so that nothing remains but the pure fibrous tissue, which serves for making parchment, consisting of coats of white [illegible]dullary fibres, and which has a resemblance to a swine's bladder softened in water.

"After this preparation, the workmen take a certain kind of frames called *pilon*, made of a straight and a semicircular piece of wood, having nearly the same form as the skins. On these the skins are extended in as smooth and even a manner as possible by means of cords; and during the operation of extending them, they are several times besprinkled with water, that no part of them may be dry, and occasion an unequal tension. After they have been all extended on the frames, they are again moistened, and carried into the house, where the frames are deposited close to each other on the floor with the flesh side of the skin next the ground. The upper side is then thickly bestrewed with the black exceedingly smooth and hard seeds of a kind of goose foot (*chenopodium album*), which the Tartars call *alabuta*, and which grows in abundance, to about the height of a man, near the gardens and farms on the south side of the Volga; and that they may mak[e a] strong impression on the skins, a piece of felt is spread over them, and the seeds are trod down with the feet, by which means they are deeply imprinted into the soft skins. The frames, without shaking the seeds, are then carried out into the open air, and placed in a reclining position against a wall to dry, the side covered with the seeds being next the wall, in order that it may be sheltered from the sun. In this state the skins must be left several days to dry in the sun, until no appearance of moisture is observed in them, when they are fit to be taken from the frames. When the impressed seeds are beat off from the hair side, it appears full of indentations or inequalities, and has acquired that impression which is to produce the grain of the shagreen, after the skins have been subjected to the last smoothing or scraping, and have been dipped in a ley, which will be mentioned hereafter, before they receive the dye.

"The operation of smoothing is performed on an inclined bench or board, which is furnished with an iron hook, and is covered with thick felt of sheep's wool, on

Shagreen. on which the dry skin may gently rest. The skin is suspended in the middle of the bench or board to its iron hook, by means of one of the holes made in the edge of the skin for extending it in its frame as before mentioned; and a cord, having at its extremity a stone or a weight, is attached to each end of the skin, to keep it in its position while under the hands of the workman. It is then subjected to the operation of smoothing and scraping by means of two different instruments. The first used for this purpose, called by the Tartars *tokar*, is a piece of sharp iron bent like a hook, with which the surface of the shagreen is pretty closely scraped to remove all the projecting inequalities. This operation, on account of the corneous hardness of the dry skin, is attended with some difficulty; and great caution is at the same time required that too much of the impression of the *alabuta* seed be not destroyed, which might be the case if the iron were kept too sharp. As the iron, however, is pretty blunt, which occasions inequalities on the shagreen, this inconvenience must afterwards be remedied by means of a sharp scraping iron or *urak*, by which the surface acquires a perfect uniformity, and only faint impressions of the *alabuta* seed then remain, and such as the workman wishes. After all these operations, the shagreen is again put into water, partly to make it pliable, and partly to raise the grain. As the seeds occasion indentations in the surface of the skin, the intermediate spaces, by the operations of smoothing and scraping, lose some part of their projecting substance; but the points which have been depressed, and which have lost none of their substance, now swell up above the scraped parts, and thus form the grain of the shagreen. To produce this effect, the skins are left to soak in water for 24 hours; after which they are immersed several times in a strong warm ley, obtained, by boiling, from a strong alkaline earth named *schora*, which is found in great abundance in the neighbourhood of Astracan. When the skins have been taken from this ley, they are piled up, while warm, on each other, and suffered to remain in that state several hours; by which means they swell, and become soft. They are then left 24 hours in a moderately strong pickle of common salt, which renders them exceedingly white and beautiful, and fit for receiving any colour. The colour most usual for these skins is a sea-green; but old experienced workmen can dye them blue, red, or black, and even make white shagreen

"For the green colour nothing is necessary but filings of copper and sal ammoniac. Sal ammoniac is dissolved in water till the water is completely saturated; and the shagreen skins, still moist, after being taken from the pickle, are washed over with this solution on the ungrained flesh side, and when well moistened a thick layer of copper filings is strewed over them: the skins are then folded double, so that the side covered with the filings is innermost. Each skin is then rolled up in a piece of felt; the rolls are all ranged together in proper order, and they are pressed down in an uniform manner by some heavy bodies placed over them, under which they remain 24 hours. During that period, the solution of sal ammoniac dissolves a quantity of the cupreous particles sufficient to penetrate the skin and to give it a sea-green colour. If the first application be not sufficient, the process is repeated in the same manner; after which the skins are spread out and dried.

"For the blue dye, indigo is used. About two pounds of it, reduced to a fine powder, are put into a kettle; cold water is poured over it, and the mixture is stirred round till the colour begins to be dissolved. Five pounds of pounded *alakar*, which is a kind of barilla or crude soda, prepared by the Armenians and Calmucs is then dissolved in it, with two pounds of lime and a pound of pure honey, and the whole is kept several days in the sun, and during that time frequently stirred round. The skins intended to be dyed blue must be moistened only in the natrous ley *schora*, but not in the salt brine. When still moist, they are folded up and sewed together at the edge, the flesh side being innermost, and the shagreened hair side outwards; after which they are dipped three times in the remains of an exhausted kettle of the same dye, the superfluous dye being each time expressed; and after this process they are dipped in the fresh dye prepared as above, which must not be expressed. The skins are then hung up in the shade to dry; after which they are cleaned and paired at the edges.

"For black shagreen, gall-nuts and vitriol are employed in the following manner:—The skins, moist from the pickle, are thickly bestrewed with finely pulverised gall nuts. They are then folded together, and laid over each other for 24 hours. A new ley, of bitter saline earth or *schora*, is [the ...]red, and poured hot into [...] In [...]y each skin is several times [...]e again bestrewed with [...] for a certain [...] penetrate them, and the [...] from the dust of [...] are rubbed [...] tallow, [...] imbibe [...] med also [...] squeeze it w[...] in order to [...] superfluous particles are [...] wooden scraper (*urgc*); and [...]ed, and the skins have lain some time, [...]tity of vitriol of iron is dissolved [...] which the shagreen is moistened on [...] operation it [...] It is then dressed at the [...] where there are any blemis[hes.]

"To obtain white shagreen, the skins must first be moistened on the shagreen side with a strong solution of alum. When the skin has imbibed this liquor, it is daubed over on both sides with a paste made of flour, which is suffered to dry. The paste is then washed off with alum-water, and the skin is placed in the sun till it is completely dry. As soon as it is dry, it is gently besmeared with pure melted sheep's tallow, which it is suffered to imbibe in the sun; and to promote the effect, it is pressed and worked with the hands. The skins are then fastened in succession to the before-mentioned bench, where warm water is poured over them, and the superfluous fat is scraped off with a blunt wooden instrument. In the last operation the warm water is of great service. In this manner shagreen perfectly white is obtained, and nothing remains but to pare the edges and dress it.

"But this white shagreen is not intended so much for

Shagreen. Sharp.

for remaining in that state, as for receiving a dark red dye; because, by the above previous process, the colour becomes much more perfect. "The skins destined for a red colour must not be immersed first in ley of bitter salt earth (*schora*), and then in pickle, but after they have been whitened, must be left to soak in the pickle for 24 hours. The dye is prepared from cochineal, which the Tartars call *kirmitz*. About a pound of the dried herb *tschagann*, which grows in great abundance in the neighbourhood of Astracan, and is a kind of soda plant or kali (*salsola ericoides* (A)), is boiled a full hour in a kettle containing about four common pailfuls of water; by which means the water acquires a greenish colour. The herb is then taken out, and about half a pound of pounded cochineal is put into the kettle, and the liquor is left to boil a full hour, care being taken to stir it that it may not run over. About 15 or 20 drams of a substance which the dyers call *lüter* (orchilla) is added, and when the liquor has been boiled for some time longer, the kettle is removed from the fire. The skins taken from the pickle are then placed over each other in troughs, and the dye liquor is poured over them four different times, [illegible]bed into them with the hands, th[illegible]ually imbibed and diffused. The [illegible]pressed; after which they are fit [illegible] dried. [illegible] prepared in this manner are [illegible] than any of the other kinds."

SHARP (Abraham), an eminent mathematician, mechanist, and astronomer, was descended from an ancient family at Little Horton, near Bradford, in the West Riding of Yorkshire, where he was born about the year [illegible]. [illegible] he was put apprentice to a mer[illegible]; but his genius led him to [illegible] both theoretical and practical [illegible] in that situation of life. By the [illegible] therefore, of his master and [illegible] with that of his father, he quitted the business of a merchant. Upon this he removed to Liverpool, where he gave himself up wholly to the study of mathematics, astronomy, &c.; and where, for a subsistence, he opened a school, and taught writing and accounts, &c.

He had not been long at Liverpool when he accidentally fell in company with a merchant or tradesman visiting that town from London, in whose house it seems the astronomer Mr Flamsteed then lodged. With the view therefore of becoming acquainted with this eminent man, Mr Sharp engaged himself with the merchant as a book-keeper. In consequence he soon contracted an intimate acquaintance and friendship with Mr Flamsteed, by whose interest and recommendation he obtained a more profitable employment in the dock-yard at Chatham; where he continued till his friend and patron, knowing his great merit in astronomy and mechanics, called him to his assistance, in contriving, adapting, and fitting up the astronomical apparatus in the Royal Observatory at Greenwich, which had been built, namely, about the year 1676. He was principally employed in the construction of the mural arch; which in the compass of 14 months he finished so greatly to the satisfaction of Mr Flamsteed, that he speaks of him in terms of the highest praise. According to Mr Smeaton, this was the first good and valid instrument of the kind; and Mr Sharp the first artist who cut accurate and delicate divisions upon astronomical instruments. At the time this instrument was constructed, Mr Flamsteed was 30 and Mr Sharp 25 years of age.

Sharp.

These two friends continued together for some time, making observations on the meridional zenith distances of the fixed stars, sun, moon, and planets, with the times of their transits over the meridian; also the diameters of the sun and moon, and their eclipses, with those of Jupiter's satellites, the variation of the compass, &c.

Mr Sharp assisted Mr Flamsteed also in making a catalogue of near 3000 fixed stars, with their longitudes and magnitudes, their right ascensions and polar distances, with the variations of the same while they change their longitude by one degree.

But from the fatigue of continually observing the stars at night, in a cold thin air, joined to a weakly constitution, he was reduced to a bad state of health; for the recovery of which he desired leave to retire to his house at Horton; where, as soon as he found himself on the recovery, he began to fit up an observatory of his own; having first made an elegant and curious engine for turning all kinds of work in wood or brass, with a maundril for turning irregular figures, as ovals, roses, wreathed pillars, &c. Beside these, he made himself most of the tools used by joiners, clockmakers, opticians, mathematical instrument makers, &c. The limbs or arcs of his large equatorial instrument, sextant, quadrant, &c. he graduated with the nicest accuracy, by diagonal divisions into degrees and minutes. The telescopes he made use of were all of his own making, and the lenses ground, figured, and adjusted with his own hands.

It was at this time that he assisted Mr Flamsteed in calculating most of the tables in the second volume of his *Historia Cœlestis*, as appears by their letters, to be seen in the hands of Mr Sharp's friends at Horton. Likewise the curious drawings of the charts of all the constellations visible in our hemisphere, with the still more excellent drawings of the planispheres both of the northern and southern constellations. And though these drawings of the constellations were sent to be engraved at Amsterdam by a masterly hand, yet the originals far exceeded the engravings in point of beauty and elegance: these were published by Mr Flamsteed, and both copies may be seen at Horton.

The mathematician, says Dr Hutton, meets with something extraordinary in Sharp's elaborate treatise of *Geometry Improved* (in 4to, 1717, signed A. S. Philomath): 1st, by a large and accurate table of segments of circles, its construction and various uses in the solution of several difficult problems, with compendious tables for

(A) The beautiful red Turkey leather is dyed with cochineal prepared in the same manner. Professor Gmelin junior, in the second part of his Travels through Russia, explains the herb *tschagann* by *artemisia annua*, having doubtless been deceived by the appearance the plant acquires after it has been dried. Besides, this *artemisia* is found only in the middle of Siberia, and never on the west side of the Irtisch.

for finding a true proportional part; and their use in these or any other tables exemplified in making logarithms, or their natural numbers, to 60 places of figures; there being a table of them for all primes to 1100, true to 61 figures. 2d. His concise treatise of Polyedra, or solid bodies of many bases, both the regular ones and others: to which are added twelve new ones, with various methods of forming them, and their exact dimensions in surds, or species, and in numbers; illustrated with a variety of copperplates, neatly engraved by his own hands. Also the models of these polyedra he cut out in boxwood with amazing neatness and accuracy. Indeed few or none of the mathematical instrument makers could exceed him in exactly graduating or neatly engraving any mathematical or astronomical instrument, as may be seen in the equatorial instrument above mentioned, or in his sextant, quadrants, and dials of various sorts; also in a curious armillary sphere, which, beside the common properties, has moveable circles, &c. for exhibiting and resolving all spherical triangles; also his double sector, with many other instruments, all contrived, graduated, and finished, in a most elegant manner, by himself. In short, he possessed at once a remarkably clear head for contriving, and an extraordinary hand for executing, any thing, not only in mechanics, but likewise in drawing, writing, and making the most exact and beautiful schemes or figures in all his calculations and geometrical constructions.

The quadrature of the circle was undertaken by him for his own private amusement in the year 1699, deduced from two different series, by which the truth of it was proved to 72 places of figures; as may be seen in the introduction to Sherwin's Tables of Logarithms; that is, if the diameter of a circle be 1, the circumference will be found equal to 3·14159265358979323846264338327950288419716939937510582097494459230781640 5, &c. In the same book of Sherwin's may also be seen his ingenious improvements on the making of logarithms, and the constructing of the natural sines, tangents, and secants.

He also calculated the natural and logarithmic sines, tangents, and secants, to every second in the first minute of the quadrant; the laborious investigation of which may probably be seen in the archives of the Royal Society, as they were presented to Mr Patrick Murdoch for that purpose; exhibiting his very neat and accurate manner of writing and arranging his figures, not to be equalled perhaps by the best penman now living.

Mr Sharp kept up a correspondence by letters with most of the eminent mathematicians and astronomers of his time, as Mr Flamsteed, Sir Isaac Newton, Dr Halley, Dr Wallis, Mr Hodgson, Mr Sherwin, &c. the answers to which letters are all written upon the backs, or empty spaces, of the letters he received, in a short-hand of his own contrivance. From a great variety of letters (of which a large chestful remain with his friends) from these and many other celebrated mathematicians, it is evident that Mr Sharp spared neither pains nor time to promote real science. Indeed, being one of the most accurate and indefatigable computers that ever existed, he was for many years the common resource for Mr Flamsteed, Sir Jonas Moore, Dr Halley, and others, in all sorts of troublesome and delicate calculations.

Mr Sharp continued all his life a bachelor, and spent his time as recluse as a hermit. He was of a middle stature, but very thin, being of a weakly constitution. He was remarkably feeble the last three or four years before he died, which was on the 18th of July 1742, in the 91st year of his age.

In his retirement at Little Horton, he employed four or five rooms or apartments in his house for different purposes, into which none of his family could possibly enter at any time without his permission. He was seldom visited by any persons, except two gentlemen of Bradford, the one a mathematician, and the other an ingenious apothecary; these were admitted, when he chose to be seen by them, by the signal of rubbing a stone against a certain part of the outside wall of the house. He duly attended the dissenting chapel at Bradford, of which he was a member, every Sunday; at which time he took care to be provided with plenty of halfpence, which he very charitably suffered to be taken singly out of his hand, held behind him during his walk to the chapel, by a number of poor people who followed him, without his ever looking back, or asking a single question.

Mr Sharp was very irregular as to his meals, and remarkably sparing in his diet, which he frequently took in the following manner. A little square hole, something like a window, made a communication between the room where he was usually employed in calculations, and another chamber or room in the house where a servant could enter; and before this hole he had contrived a sliding board: the servant [illegible] placed his victuals in this hole, without speaking [illegible] any the least noise; and when he [illegible] he visited his cupboard to see what [illegible] his hunger or thirst. But [illegible] e breakfast, dinner, and supper [illegible] untouched by him, when the servant has gone to remove what was left—so deeply engaged had he been in calculations.

SHARPS in fount, the finer part of what we have denominated POLLARDS. See that article, *Suppl.*

SHASTAH, the same as SHASTER; which see, *Encycl.*

SHEA, the name of a tree, from the fruit of which the Negroes, in the interior [illegible] of Africa between the tropics, prepare a kind of [illegible]. These trees are not planted by the [illegible] are found growing naturally in the woods [illegible] ring wood land for cultivation, every tree [illegible] wn but the Shea. The tree itself very much [illegible] the American oak; and the fruit, from the kernel of which being first dried in the sun the butter is prepared, by boiling the kernel in water, has somewhat the appearance of a Spanish olive. The kernel is enveloped in a sweet pulp, under a thin green rind; and the butter produced from it, besides the advantage of its keeping the whole year without salt, is whiter, firmer, and, Mr Park says, to his palate, of a richer flavour than [illegible] best butter which he ever tasted made from cows [illegible] The growth and preparation of this commodity [illegible] to be among the first objects of African indu[illegible] this and the neighbouring states; and it constitutes [illegible] main article of their inland commerce. In some places they dry the fruit in kilns, containing each about half a cart load of fruit, under which is kept up a clear wood fire. Our author, who saw the fruit in one of these kilns, was informed, that in three days the fruit would

Sheave, Shebbeare.

would be ready for pounding and boiling; and that the butter thus manufactured, is preferable to that which is prepared from fruit dried in the sun; especially in the rainy season, when the process by insolation is always tedious, and oftentimes ineffectual. Might it not be worth while, if practicable, to cultivate Shea-trees in some of our West India islands?

SHEAVE, in mechanics, a solid cylindrical wheel, fixed in a channel, and moveable about an axis, as being used to raise or increase the mechanical powers applied to remove any body.

SHEBBEARE (John) was born at Bideford, a considerable sea-port and corporation town in Devonshire, in the year 1709. His father was an attorney; but having small practice and little fortune, he carried on also the business of a corn-factor. He had four children, two sons and two daughters. Of the sons, John, the subject of our present memoir, was the eldest. The other son was called Richard, and entirely the reverse of his brother in disposition; he was bred to the sea, and died young.

John received the rudiments of his education at the free grammar school of Exeter, then conducted by the learned Mr Zachary Mudge (author of an Essay for a new Version of the Psalms, and a volume of excellent Sermons), afterwards Rector of St Andrew in Plymouth. It has oftentimes been remarked, that the future life of a man may be nearly guessed at from his puerile character. Thus Shebbeare, while a schoolboy, gave the strongest indications of his future emi- [illegible] arkable [illegible] ness of his [illegible] of his disposition; being universal [illegible] d of satirising genius, while at [illegible] generally [illegible] for his malicious and [illegible]. This may easily be believed, when [illegible] formed not one connection, either a[illegible] any person in the way of [illegible] with a young barber of an [illegible], whose soul was perfectly congenial to that of Shebbeare's.

Such is the account of Shebbeare's boyish years which we have in the 14th volume of the *European Magazine*. It is probably much exaggerated; for Shebbeare continued through life a staunch Tory, if not a Jacobite; and it is well known that many of our journalists consider themselves as at liberty to give what characters they please of such men.

In the fifteenth or sixteenth year of his age, young Shebbeare was bound apprentice to a very eminent and worthy surgeon in his native town; in which situation he acquired a considerable share of medical knowledge. His genius for lampoon appeared at this early period, and he could not forbear from exercising it on his master. No one indeed could give him the slightest offence with impunity; for which reason almost every [illegible]n avoided his acquaintance, as we would avoid the sting of an adder. The chief marks, however, of the [illegible] of his wit were the gentlemen of the corpora[illegible] one or other, and sometimes all of them, were almost constantly exposed in a libel upon the public posts and corners of the streets. But though the wiser part of them only laughed at these harmless trifles, yet some were more irritable, and many a prosecution was commenced against, but not one could fix itself upon him, so artfully had h[e] contrived to conceal himself. He was also several times summoned to appear at the sessions, for daring to speak and write irreverently of the worshipful magistrates; but the laugh was always on the side of Shebbeare, nor could they ever come at his back, so closely had he fitted on his armour, with the whip of authority.

When he was out of his time he set up trade for himself, and then shewed a taste for chemistry; and soon after he married a very agreeable and amiable young woman, of no fortune, but of a genteel family. Whether his insuperable propensity to satire deprived him of friends and of business, or that he spent too much in chemical experiments, we know not; but failing at Bideford, he removed, about the year 1736, to Bristol, where he entered into partnership with a chemist, and never afterwards set his foot in his native town.

In the year 1739 he attracted the attention of the public, by an epitaph to the memory of Thomas Coster, Esq; member for Bristol; in which, it has been truly observed, that he has contrived to raise emotions of pity, grief, and indignation, to a very high degree. The next year he published a pamphlet on the Bristol waters; from which period there is a chasm in our author's life we are unable to fill up. In this interval may probably be placed his failure in business, and his effort to obtain a higher situation in his profession. It is certain that in the year 1752 he was at Paris, and there he obtained the degree, if he obtained it at all, which gave him the addition to his name which accompanied him during the rest of his life, that of Doctor. Until this time he appears to have lived in obscurity; but at an age when vigorous exertion usually subsides, he seems to have resolved to place himself in a conspicuous situation, whatever hazard might attend it, and commenced a public writer with a degree of celerity and virulence for which it would be difficult to find a parallel even in the most intemperate times. To read over his works now, when the passions they then raised have subsided, we feel surprise at the effect they produced; and it is within the memory of many yet living, that their influence was very considerable. In the year 1754 he began his career with The Marriage Act, a political novel; in which he treated the legislature with such freedom, that it occasioned his being taken into custody, from whence, however, he was soon released.

The performances, however, most celebrated, were a series of Letters to the People of England, which were written in a style vigorous and energetic, though slovenly and careless, well calculated to make an impression on common readers; and were accordingly read with avidity, and circulated with diligence. They had a very considerable effect on the minds of the people, and galled the ministry, who seem to have been at first too eager to punish the author. On the publication of the Third Letter, we find warrants, dated 5th and 8th of March, 1756, issued by Lord Holdernesse, to take up both Scott the publisher and the author. This prosecution, however, seems to have been dropt, and the culprit proceeded for some time unmolested, "having declared (says one of his answerers) that he would write himself into a post or into the pillory; in the last of which he at length succeeded." On the 12th of January 1758, a general warrant was signed by Lord Holdernesse, to search for the author,

printer,

printer, and publishers of a wicked, audacious, and treasonable libel, entitled, "A Sixth Letter to the People of England, on the progress of national ruin; in which is shewn that the present grandeur of France and calamities of this nation are owing to the influence of Hanover on the councils of England;" and them having found, to seize and apprehend, together with their books and papers.

At this juncture government seem to have been effectually roused; for having received information that a seventh letter was printing, by virtue of another warrant, dated January 23, all the copies were seized and entirely suppressed. In Easter Term an information was filed against him by Mr Pratt, then attorney general, afterwards Lord Camden; in which it is now worthy of remark, that the crown officer, in his application to the court, in express terms admitted a point, since much disputed, that of the jury's right to determine both the law and the fact in matters of libel. "What I urge (says the advocate) to the court, is only to shew there is reasonable ground for considering this publication as a libel, and for putting it in a way of trial, and therefore it is I pray to have the rule made absolute; for I admit, and your lordship well knows, that the jury in matter of libel are judges of the law as well as the fact, and have an undoubted right to consider whether, upon the whole, the pamphlet in question be, or be not, a false, malicious, and scandalous libel." On the 17th of June, the information was tried, when our author was found guilty; and on the 28th November, he received sentence, by which he was fined five pounds, ordered to stand in the pillory December 5, at Charing Cross, to be confined three years, and to give security for his good behaviour for seven years, himself in 500l. and two others in 250l. each.

On the day appointed, that part of the sentence which doomed him to the pillory was put in execution, amidst a prodigious concourse of people assembled on the occasion. The under sheriff, at that time, happened to be Mr Beardmore, who had sometimes been assisted by the Doctor in writing the Monitor, a paper in its principles of the same tendency with the writings of the culprit, who consequently might expect every indulgence from the officer to whom the execution of his sentence was committed. The manner in which it was conducted may be learned from the affidavits on which afterwards the under sheriff's conduct became the subject of animadversion in the court of King's Bench, and which assert, "that the defendant only stood upon the platform of the pillory, unconfined, and at his ease, attended by a servant in livery (which servant and livery were hired for the occasion only) holding an umbrella over head all the time: but his head, hands, neck, and arms, were not at all confined, or put into the holes of the pillory; only that he sometimes put his hands upon the holes of the pillory in order to rest himself." For this neglect of duty, Beardmore was fined 50l. and suffered two months imprisonment.

Some time before he was tried for the obnoxious publication already mentioned, the Duchess of Queensbury, as heir of Lord Clarendon, obtained an injunction in the Court of Chancery to stop the publication of the continuation of that nobleman's history; a copy of which had got into the hands of Francis Gwyn, Esq; between whom and the Doctor there had been an agreement to publish it and equally divide the profits. The care and expences attending the ushering this work into the world were to be wholly Dr Shebbeare's, who performed his part of the agreement, and caused it to be handsomely printed in quarto, with a Tory preface, containing frequent reflections on, and allusions to recent events, and to living characters, which gave it the appearance rather of a temporary pamphlet than of a work calculated for posterity. On the injunction being obtained, Dr Shebbeare was under the necessity of applying to the aid of law to recover the money expended by him in printing, amounting to more than 500l. Of that sum more than half had been wasted on his side in the courts of law and equity. And some years afterwards, speaking of the situation of his affairs, he says, "It may be easily imagined, that my circumstances were not improved by three years imprisonment. I had no club of partizans to maintain me during that time, to discharge my debts, nor even the fine, which I was obliged to pay after a three years confinement for a single offence. Notwithstanding the difficulties which inevitably arose from these particulars, and although an insolvent act was passed soon after his Majesty's accession to the throne, and my circumstances might have apologised for my taking that opportunity which is offered; I nevertheless declined from availing myself of that occasion to evade the payment of my debts. I preferred the labour of endeavouring to pay them, and the risk of being again imprisoned if I did not succeed. But, thank Heaven, I am in no [illegible] ment on that account." [illegible] he declares he never received [illegible] than twenty guineas from all the world.

While he was confined in the King's Bench, he solicited subscriptions for the first volume of a History of England, from the Revolution to the then present time. But at the persuasion of his friends he was induced to alter his design, and receipts were issued for a first volume of the History of England, and of the Constitution thereof, from its origin. That volume he wrote, and had transcribed. "But as it was impracticable (to use his own words), whilst I was in confinement, to procure that variety of books, as to apply to manuscript authorities, for all that was requisite to the completing of this first volume, I found, on being released from my imprisonment, and on application to the former only, that the volume which I had written was incorrect, insufficient, and erroneous, in too many particulars, to admit of its being published, without injustice to my subscribers, and reprehensions on myself. Into this displeasing situation I had been misled by relying on the authorities of modern historians, who pretend to cite the authors from whence their materials are taken, many of whom appear never to have seen them, but implicitly to have copied one another, and all of them manifestly defective; not only in the authorities they should have sought, but in their omissions and misrepresentations of those whom they had consulted: more especially respecting those parts of the old German codes, on which our constitution is erected, and without which it cannot be properly explained or understood. Such being the real situation of things, I perceived that more time than I could expect to live would be necessarily required for so extensive a work as the

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the whole history I had proposed; and that a single volume, or even a few volumes of an history incomplete would by no means answer either the intention of my subscribers, or my own: I determined therefore to change my plan, and to include in one volume that which might require no others to complete this new design.

"In consequence of this alteration, I resolved to exert my best abilities, not only to trace the constitution of England from its origin in the woods of Germany, as M. de Montesquieu expresses it, but from the first principles of human nature, from which the formation of all kinds of government is derived. With this view, I have attempted an analyzation of the mental and corporeal faculties, in order to shew in what manner they reciprocally influence each other in the various actions of man, not only as an individual, but as a gregarious being, impelled by nature to associate in communities. From hence I have attempted to delineate in what manner legislature sprang and proceeded from its source, through that variety of meanders which it hath formed in its current, both before and since the introduction of one common sign, whereby to express the intrinsic value, not only of all the productions of nature and of art, but even of the human faculties, as they are now estimated; to compare the constitutions of those different states which have been, and are the most celebrated in ancient and modern history, with each other, and with that of England; and then to derive some reasonable grounds for the determination of that which seems to be the most consentaneous with the primogenial instincts of nature, and the happiness of human kind. In consequence of this intent, the manners that successively arose and prevailed in such states, the benefits and mischiefs which ensued from them, are delineated, in order to explain on what foundation the welfare of national communities may most probably be established."

This plan, thus delineated, he at times employed himself in filling up; but on being rudely attacked for not performing his promise with his subscribers, he, in 1774, observed—"From the inevitable obligations, not only of supporting my own family, but those also whom as son and brother it was my duty to fulfill for forty years, and which, respecting the claims of the latter, still continues; it will be easily discerned that many an avocation must have proceeded from these circumstances, as well as from a sense of gratitude to his majesty, in defence of whose government I have thought it my duty occasionally to exert my best abilities." He adds, however, that he did not intend to die until what he had proposed was finished; a promise which the event has shewn he was unable to perform.

In prison he was detained during the whole time of the sentence, and with some degree of rigour; for when his life was in danger from an ill state of health, and applied to the court of King's Bench for permission carried into the rules a few hours in a day, tho' Mansfield acceded to the petition, yet the prayer of it was denied and defeated by Judge Foster. At the expiration of the time of his sentence, a new reign had commenced; and shortly afterwards, during the administration of Mr Grenville, a pension was granted him by the crown. This he obtained by the personal application of Sir John Philips to the King, who, on that occasion, was pleased to speak of him in very favourable terms, which he promised undeviatingly to endeavour to deserve by allegiance and gratitude.

Shebbeare.

From the time of that event we find Dr Shebbeare a uniform defender of the measures of Government, and the mark against whom every opposer of administration considered himself at liberty to throw out the grossest abuse. Even the friends of power were often adverse to him. Dr Smollet introduced him in no very respectful light, under the name of Ferret, in the novel of Sir Launcelot Greaves, and Mr Hogarth made him one of the group in the third election print.

Scarce a periodical publication was without some abuse of him, which he seems to have in general had the good sense to neglect. In the year 1774, however, he departed from his general practice, and defended himself from some attacks at that time made upon him. In this pamphlet he represented the conduct and character of King William in such a light as to excite the indignation of every Whig in the kingdom: he treated him in print with as great severity as Johnson used to do in conversation.

Early in life he appears to have written a comedy, which in 1766 he made an effort to get represented at Covent Garden. In 1768 he wrote the Review of Books in the Political Register for three months, and was often engaged to write for particular persons, with whom he frequently quarrelled when he came to be paid. This was the case with Sir Robert Fletcher, and we think of others. His pen seems to have been constantly employed, and he wrote with great rapidity, what certainly can now be read with little satisfaction, and must soon be forgotten. Though pensioned by government, he can scarce be said to have renounced his opinions; for in the pamphlet already mentioned, his abuse of the Revolution is as gross as in that for which he suffered the pillory. His violence defeated his own purpose, and made those who agreed in party with him revolt from the virulence with which he treated his adversaries. During the latter years of his life he seems to have written but little. He was a strenuous supporter of the ministry during the American war, having published, in 1775, An Answer to the printed Speech of Edmund Burke, Esq; spoken in the House of Commons, April 19, 1774. In which his knowledge in polity, legislature, human kind, history, commerce, and finance, is candidly examined; his arguments are fairly refuted; the conduct of administration is fully defended; and his oratoric talents are clearly exposed to view.—And An Essay on the Origin, Progress, and Establishment of National Society; in which the principles of Government, the definitions of physical, moral, civil, and religious Liberty contained in Dr Price's Observations, &c. are fairly examined, and fully refuted; together with a justification of the Legislature in reducing America to obedience by force. To which is added, an Appendix on the Excellent and Admirable in Mr Burke's second printed Speech of the 22d of March 1775, both 8vo.

His publications, satirical, political, and medical, amount to thirty-four, besides a novel, entitled Lydia, or Filial Piety; in which religious hypocrisy and blustering courage are very properly chastised. He died on the 1st of August 1788, leaving, among those who knew him best, the character of a benevolent man; a

character which, from the manner in which he speaks of his connections, he probably deserved.

SHEERS, aboard a ship, an engine used to hoist or displace the lower masts of a ship.

SHEIBON, a district in Africa, lying to the south-east of the kingdom of Dar-Fur (See SOUDAN in this volume), where much gold is found both in dust and in small pieces. The natives, who are idolaters and savages, collect the dust in quills of the ostrich and vulture, and in that condition sell it to the merchants. They have a ceremony on discovering a large piece of gold, of killing a sheep on it before they remove it. The people, who are all black, have some form of marriage, *i. e.* of an agreement between man and woman to cohabit. Women of full age wear a piece of platted grass on their parts. The younger and unmarried are quite naked. The slaves, which are brought in great numbers from this quarter, are some prisoners of war among themselves (for their wars are frequent), and some seduced by treachery, and sold. But it is said to be a common practice for a father in time of scarcity to sell his children.

At Sheibon are some Mohammedans, who live among the idolaters, and wear clothing: it is not said whether Arabs or not. Mr Browne, from whose travels we have taken this account of Sheibon, does not give its latitude or longitude.

SHILLUK, a town in Africa on the banks of the Bahr-el-abiad, or true Nile. The houses are built of clay, and the inhabitants, who are idolaters, have no other clothing than bands of long grass, which they pass round the waist and between the thighs. They are all black; both sexes are accustomed to shave their heads. The people of Shilluk have the dominion of the river, and take toll of all passengers, in such articles of traffic as pass among them. The name Shilluk is not Arabic, and its meaning is unknown.—When asked concerning their name or country, the people reply Shilluk. When employed in transporting Mohammedans across the ferry, they occasionally exhibit the importance which their situation gives them. After the Muslim has placed himself in the boat, they will ask him, "Who is the master of that river?" The other replies, as is usual, "Ullah or Rubbani"—God is the master of it. "No (answers the Shilluk), you must say that such a one (naming his chief) is the master of it, or you shall not pass." They are represented as shewing hospitality to such as come among them in a peaceable manner, and as never betraying those to whom they have once accorded protection. The particulars of their worship have not been described. In Mr Browne's map, Shilluck is placed in about 13° N. Lat. and 32° 26′ E. Long.

SHIP. See that article, and SHIPBUILDING (*Encycl.*), and likewise *FLOATING Bodies* (*Suppl.*) In the *Transactions of the Royal Society of London* for 1798, Mr Atwood has completed his disquisition on the *Stability* of Ships; but as the memoir cannot be abridged, we must refer the scientific naval architect to the original for much useful information.

A small work has lately been published by Charles Gore, Esq; of Weimar in Saxony, upon *the respective Velocity of Floating Bodies varying in Form.* It contains merely the results of two series of experiments: from the first of which series, it seems to appear that the form best calculated for velocity is a long parallel body, terminating at each end in a parabolic cuneus, and having the extreme breadth in the centre. Also, that making the cuneus more obtuse than is necessary to break with fairness the curve line into the straight, creates a considerable degree of impediment. And Mr Gore is inclined to think, that the length of ships, which has already been extended with success, to four times the breadth, is capable, with advantage, of still further extension, perhaps to five, and, in some cases, even to six times.

The second set of experiments was instituted to ascertain the respective degrees of stability, or power of resisting the pressure of the wind, in carrying sail, on bodies of different forms. The bodies used in the experiments had their specific capacities and weights precisely equal, but their forms different; and from the results, it appears that the form of a midship body, best adapted for stability only, is a flat bottom, with perpendicular sides; and that the next best adapted is a semicircle. But as there exists much difficulty in constructing the former with sufficient strength, besides its being ill adapted to heavy seas, as, by the sudden descent in pitching, the bottom will strike the water nearly at right angles, and sustain thereby a tremendous shock. And as the latter seems to be too inclinable to transverse oscillation, or rolling, and also to be deficient in capacity for many services, our author is of opinion, that a midship body, of a compounded form, is most applicable to general purposes.

On account [illegible] ue we are unable to speak critically [illegible] tract. To benefit naval architectu[illegible] on, that the method of experiment i[illegible] is than that of calculation [illegible] riments must be drawn with great caution. It is by no means certain that a result obtained for a body of a given bulk will obtain for similar bodies which differ in dimensions.

We shall conclude this short article with a statement of the principles upon which Patrick Miller, Esq; of Dalswinton (Scotland), proposes to construct ships and vessels which cannot founder.

The vessel is to be kept afloat, without the aid [illegible] sides, solely by the buoyancy of its bottom, which is flat; the bottom never being so deeply immersed as to bring the upper surface thereof on a level with the water; such vessels are being constructed for the purpose of carrying cargoes, but [illegible] with the necessary [illegible] vessels are not kept afloat by the aid of their sides, but by the buoyancy of their bottom, as above described, they cannot sink, and therefore pumps are not required, nor are they in any respect necessary for the preservation of such vessels. The said vessel is put in motion, during calms, and against light winds, by means of wheels. These wheels project beyond the sides of the vessel, and are wrought by means of capstans: the number and the dimensions of the wheels depend upon the length of the vessel. These wheels are built with eight arms, which consist entirely of plank. Sliders are used to work and to keep the vessel to windward when under sail. These sliders are placed in the centre of the vessel, from stem to stern; they are made of plank, and the number and dimensions must depend on the length of the vessel; and they are raised and let down,

down, either by the hand, or by means of a purchase, according to the size of the vessel. Vessels of this construction draw water, in proportion to their dimensions, as follows: a vessel of forty feet in length, and from thirteen to nineteen feet in breadth, will draw from thirteen to sixteen inches of water. One of fifty feet in length, and from seventeen to twenty-four feet in breadth, will draw from fifteen to eighteen inches of water. One sixty feet long, and from twenty to twenty-eight feet broad, will draw from eighteen to twenty-one inches of water. One seventy feet long, and from twenty three to thirty-two feet broad, will draw from twenty-one to twenty-four inches of water. One eighty feet long, and from twenty-seven to thirty-seven feet broad, will draw from twenty-four to twenty-seven inches of water. One ninety feet long, and from thirty to forty-two feet broad, will draw from twenty-seven to thirty inches of water. One of one hundred feet in length, and from thirty-three to forty-seven feet in breadth, will draw from thirty to thirty three inches of water.

As, from the principle upon which this vessel is constructed, she cannot sink, the invention must prove a means of saving many lives; and as it will give more room and height between the decks than any vessel of the same dimensions of another construction, it must add greatly to the comfort and [illegible] ion of persons at sea of all descriptions. It is expected that, from these advantages, a more general and friendly intercourse amongst nations will take place, which will have the effect to diffuse knowledge, and to remove national prejudices, thereby promoting the general welf[illegible] of mankind. At [illegible] Mr Miller, it [illegible] be altogether [illegible] the [illegible] of ships of greater dimensions [illegible] would be [illegible] to a purpose very [illegible] by the inventor.

SHIPWRECK, a [illegible] disaster, by which numbers of lives are yearly lost. In that valuable miscellany entitled, *The Philosophical Magazine*, we have an account of means for preventing that loss, when the ship is in danger within two or three hundred fathoms of the shore; and as the anonymous author (a Frenchman) says that he has by experiment ascertained the efficacy of these means, we shall give them to our readers.

The only certain means of [illegible] the crew of a vessel in such a state is, to establish a rope of communication from the shore to the ship. But how is this to be done? The author says, by fixing the end of [illegible] bomb or cannon ball, and extending the rope afterwards, in a zig-zag direction, before the mortar or cannon, or suspending it on a piece of wood raised several feet. A rope, so placed, will not break (he says) by the greatest velocity which can be given to the bomb or ball; and thus the end of it can be sent ashore by a discharge of artillery. He prefers the bomb to the cannon ball, for reasons which he does not assign. He proposes, however, other means to effect his benevolent purpose.

"It ought to be remembered (says he), that a vessel is never cast away, or perishes on the coast, but because it is driven thither against the will of the captain, and by the violence of the waves and the wind, which almost always blows from the sea towards the shore, without which there would be no danger to be apprehended: consequently, in these circumstances, the wind comes always from the sea, either directly or obliquely, and blows towards the shore.

"*1st*, A common paper kite, therefore, launched from the vessel and driven by the wind to the shore, would be sufficient to save a crew consisting of 1500 seamen, if such were the number of a ship of war. This kite would convey to the shore a strong packthread, to the end of which might be affixed a cord, to be drawn on board by means of the string of the kite; and with this cord a rope, or as many as should be necessary, might be conveyed to the ship.

"*2d*, A small balloon, of six or seven feet in diameter, and raised by rarified air, would be also an excellent means for the like purpose: being driven by the wind from the vessel to the shore, it would carry thither a string capable of drawing a cord with which several ropes might be afterwards conveyed to the vessel. Had not the discovery of Montgolfier produced any other benefit, it would be entitled on this account to be considered as of great importance.

"*3d*, A sky-rocket, of a large diameter, would be of equal service. It would also carry, from the vessel to the shore, a string capable of drawing a rope after it.

"*Lastly*, A fourth plan for saving the [illegible] of a [illegible]wrecked vessel, is that of throwing from the vessel into the sea an empty cask with a cord attached to it. The wind and the waves would drive the cask to the shore, and afford the means of establishing that rope of [illegible]munication already mentioned."

SILLA, a large town on the Niger, which bounded Mr Park's travels eastward. He gives no description of the place, which he had not spirits or health to survey; but fills a page of his work with the reasons which determined him to proceed no farther. "When I arrived (says he), I was suffered to remain till it was quite dark, under a tree, surrounded by hundreds of people. But their language was very different from the other parts of Bambarra; and I was informed that, in my progress eastward, the Bambarra tongue was but little understood, and that when I reached Jenné, I should find that the majority of the inhabitants spoke a different language, called *Jenné Kummo* by the Negroes, and *Kalam Soudan* by the Moors.

"With a great deal of entreaty, the Dooty allowed me to come into his baloon, to avoid the rain; but the place was very damp, and I had a smart paroxysm of fever during the night. Worn down by sickness, exhausted with hunger and fatigue, half naked, and without any article of value, by which I might procure provisions, clothes, or lodging, I began to reflect seriously on my situation. I was now convinced, by painful experience, that the obstacles to my further progress were insurmountable. The tropical rains were already set in with all their violence; the rice grounds and swamps were everywhere overflowed; and in a few days more, travelling of every kind, unless by water, would be completely obstructed. The kowries which remained of the king of Bambarra's present were not sufficient to enable me to hire a canoe for any great distance; and I had but little hopes of subsisting by charity, in a country where the Moors have such influence. But above all, I perceived that I was advancing more and more within the power of those merciless fanatics; and from my reception both at SEGO and SANSANDING (see these articles, *Suppl.*), I was apprehensive that, in attempting to reach even Jenné (unless under the protection of some man of consequence amongst them, which I had

no

Sillon || Siwa

no means of obtaining), I should sacrifice my life to no purpose; for my discoveries would perish with me. The prospect either way was gloomy. In returning to the Gambia, a journey on foot of many hundred miles presented itself to my contemplation, through regions and countries unknown. Nevertheless, this seemed to be the only alternative; for I saw inevitable destruction in attempting to proceed to the eastward. With this conviction on my mind, I hope my readers will acknowledge that I did right in going no farther. I had made every effort to execute my mission in its fullest extent which prudence could justify. Had there been the most distant prospect of a successful termination, neither the unavoidable hardships of the journey, nor the dangers of a second captivity, should have forced me to desist. This, however, necessity compelled me to do; and whatever may be the opinion of my general readers on this point, it affords me inexpressible satisfaction, that my honourable employers have been pleased, since my return, to express their full approbation of my conduct." He would be a very unreasonable man, indeed, who could on this point think differently from Mr Park's employers. Silla is placed in the new map of Africa in about 14° 48′ N. Lat. and 1° 24′ W. Long.

SILLON, in fortification, an elevation of earth, made in the middle of the moat, to fortify it, when too broad. It is more usually called the *envelope*.

SIMANCAS, a village on the eastern limit of the kingdom of Leon in Spain, two leagues below Valladolid, on the river Gisuerga. It is mentioned by Dr Robertson in the introduction to his History of America, and is remarkable for the archives or register office of the kingdoms of Leon and Castile, kept in the castle there. This collection was begun when the kings resided often at Valladolid; in which city to this day is the chancery or civil and criminal tribunal for almost all Spain to the north of the Tagus. It was thought convenient to have those papers kept in the neighbourhood of that court; and this castle was particularly fit for that purpose, as it is all built of stone. Some years ago there were two large halls in this office filled with papers relating to the first settlement of the Spaniards in South America. There was also in the room called the *ancient royal patronage* a box containing treaties with England, in which are many letters and treaties between the kings of England and Spain from about the year 1400 down to 1600. There was also in the same archives a strong box, with five locks, which, it is said, has not been opened since the time of Philip II. and it is conjectured that it contains the process against Philip's son Prince Charles. But it seems some of the state papers have been removed to Madrid.

SITUS, in algebra and geometry, denotes the situation of lines, surfaces, &c. Wolfius delivers some things in geometry, which are not deduced from the common analysis, particularly matters depending on the *situs* of lines and figures. Leibnitz has even founded a particular kind of analysis upon it, called *calculus situs*.

SIWA, a town in Egypt, to the westward of Alexandria, built on a small fertile spot or Oasis, which is surrounded on all sides by desert land. A large proportion of this space is filled with date trees; but there are also pomegranates, figs, and olives, apricots, and plantains; and the gardens are remarkably flourishing. They cultivate a considerable quantity of rice, which, however, is of a reddish hue, and different from that of the Delta. The remainder of the cultivable land furnishes wheat enough for the consumption of the inhabitants. Water, both salt and fresh, abounds; but the springs which furnish the latter are most of them tepid; and such is the nature of the water, air, and other circumstances, that strangers are often affected with agues and malignant fevers.

The greatest curiosity about Siwa is a ruin of undoubted antiquity, which, according to Mr Browne, resembles too exactly those of the Upper Egypt, to leave a doubt that it was erected and adorned by the same intelligent race of men. The figures of Isis and Anubis are conspicuous among the sculptures; and the proportions are those of the Egyptian temples, though in miniature. What of it remains is a single apartment, built of massy stones, of the same kind as those of which the pyramids consist; and covered originally with six large and solid blocks, that reach from one wall to the other. The length is 32 feet in the clear, the height about 18, the width 15. A gate, situated at one extremity, forms the principal entrance; and two doors, also near that extremity, open opposite to each other. The other end is quite ruinous; but, judging from circumstances, it may be imagined that the building has never been much larger than it now is. There is no appearance of any other edifice having been attached to it, and the less so as there are remains of sculpture on the exterior of the walls. In the interior are three rows of emblematical figures, apparently designed to represent a procession; and the space between them is filled with hieroglyphic characters, properly so called. The people of Siwa have no [illegible] concerning this edifice, nor attribute to it [illegible]y, but that of concealing treasures, a[illegible] of demons. It has, however, been [illegible]h some degree of probability, that Siwa is the [illegible]m of Pliny, and that this building was coeval wit[illegible] famous temple of Jupiter Ammon, and a depend[illegible] on it. This may be so; but neither the natives [illegible] Siwa, nor the various tribes of Arabs who frequent that place, know any thing of the ruins of that temple, about which Mr Browne made every possible enquiry. "It may (as he observes) still survive the lapse of ages, yet remain unknown to the Arabs, who traverse the wide expanse of the desert; but such a circumstance is scarcely probable. It may be completely overwhelmed in the sand; but this is hardly within the compass of belief."

The complexion of the people of Siwa is generally darker than that of the Egyptians. Their dialect is also different. They are not in the habitual use either of coffee or tobacco. Their sect is that of Malik. The dress of the lower class is very simple, they being almost naked: among those whose costume was discernible, it approaches nearer to that of the Arabs of the desert than of the Egyptians or Moors. Their clothing consists of a shirt of white cotton, with large sleeves, and reaching to the feet; a red Tunisine cap, without a turban; and shoes of the same colour. In warm weather they commonly cast on the shoulder a blue and white cloth, called in Egypt *melayé*; and in winter they are defended from the cold by an *ihhram* or blanket. The list of their household furniture is very short; some earthen ware made by themselves, and a few mats, form the chief part of it, none but the richer order being

being poſſeſſed of copper utenſils. They occaſionally purchaſe a few ſlaves from the Murzouk caravan. The remainder of their wants is ſupplied from Cairo or Alexandria, whither their dates are tranſported, both in a dry ſtate and beaten into maſh, which when good in ſome degree reſembles a ſweet meat. They eat no large quantity of animal food; and bread of the kind known to us is uncommon. Flat cakes, without leaven, kneaded, and then half baked, form part of their nouriſhment. The remainder conſiſts of thin ſheets of paſte, fried in the oil of the palm tree, rice, milk, dates, &c. They drink in great quantities the liquor extracted from the date-tree, which they term *date tree water*, though it have often, in the ſtate they drink it, the power of inebriating. Their domeſtic animals are, the hairy ſheep and goat of Egypt, the aſs, and a very ſmall number of oxen and camels. The women are veiled, as in Egypt. After the rains, the ground in the neighbourhood of Siwa is covered with ſalt for many weeks. Siwa is ſituated in 29° 12′ N. Lat. and 44° 54′ E. Long.

SKIRMISH BAY, the name given by Lieutenant Broughton to a bay in an iſland, which was diſcovered by him in latitude 43° 48′ ſouth, and in longitude 183° eaſt. The Chatham armed tender, which Mr Broughton commanded, under Captain Vancouver in his voyage of diſcovery, worked up into the bay, and came to anchor about a mile from the ſhore. The Lieutenant, the maſter, and one of the mates, landed, and found the people ſo extremely inhoſpitable, that they were obliged to fire upon them in their own defence. The land, whether iſland or continent, is of conſiderable magnitude; the part which they ſaw extended nearly 40 miles from eaſt to weſt; and the appearance of the country, according to the deſcription given, is very promiſing. In many reſpects the natives reſemble thoſe of New Zealand; from which country they are diſtant about 100 leagues; but their ſkins were deſtitute of any marks, and they had the appearance of being cleanly in their perſons. Their dreſſes were of ſeal or ſea-bear ſkin, and ſome had fine woven mats faſtened round the waiſt. "They ſeemed a cheerful race; our converſation (ſays Mr Broughton) frequently exciting violent burſts of laughter amongſt them. On our firſt landing, their ſurpriſe and exclamations can hardly be imagined; they pointed to the ſun, and then to us, as if to aſk, whether we had come from thence?" Their arms were ſpears, clubs, and a ſmall weapon reſembling the New Zealand patoo.

SLIDING-RULE (ſee that article, as likewiſe GAUGING-*Rod*, GEOMETRY, and *Logarithmic Lines*, Encycl.) is introduced here, for the ſake of a new, and (except in working direct proportions) a more commodious method than the common, of applying the ſlider. This method, which is propoſed by the Rev. W. Pearſon of Lincoln, is as follows:

Invert the ſlider B on any common ſliding rule, whereby the numerical figures will aſcend on it, and on the fixed line A, in contrary directions: now, as the diſtance from unity to any multiplier, on Gunter's line, will invariably extend from any multiplicand to their product, it follows, that if any particular number on the inverted ſlider B be placed oppoſite to any other given number on A, the product of thoſe numbers will ſtand on the ſlider B, againſt unity on A; for, in any poſition of the inverted ſlider, the diſtance from unity to the multiplier on A, inſtead of being carried forward on B, as when the ſlider is in a direct poſition, is brought back thereby to unity again; ſo that unity (or *ten* on ſingle lines where the ſlider is too ſhort for the operation) is invariably the index for the product of any two coincident numbers throughout the lines.

In diviſion, by the ſame proceſs, if the dividend on B be put to the index, or unity on A, the diviſion and quotient will coincide on the two oppoſite lines; ſo that when one is given, and ſought for on either line, the other is ſeen on its oppoſite line at the ſame time.

The next operation which offers itſelf here is reciprocal proportion, which can be effected by no other method than by inverting the ſlider, but which is rendered as eaſy by this application, as direct proportion is in the common way; for if any antecedent number on B inverted be ſet to its conſequent on A, any other antecedent on B, in the ſame poſition, will ſtand againſt its conſequent on A, ſo as that the terms may be in a reciprocal ratio. In ſquaring any number, it will appear, from what has been already ſaid, that if the number to be ſquared be placed on B, inverted againſt the ſame on A, the ſquare will ſtand on B, againſt unity on A. Therefore, to extract the ſquare root of any number, let that number on B ſtand againſt unity on A; and then wherever the coincident numbers are both of the ſame value, that point indicates the root. If two dividing lines of the ſame value do not exactly coincide, the coincident point will be at the middle of the ſpace contained between thoſe two which are neareſt a coincidence; and as there is only one ſuch point, there can be no miſtake in readily aſcertaining it. The finding of a mean proportional between any two numbers is extremely eaſy at one operation; for if one of the numbers on B inverted be ſet to the other on A, the coincident point of two ſimilar numbers ſhews either of thoſe to be the mean, or ſquare root of their product, according to the preceding proceſs. Thus have we a ſhort and eaſy method of multiplying, dividing, working reciprocal proportion, ſquaring and extracting the ſquare root, at one poſition of the inverted ſlider, whereby the eye is directed to only one point of view for the reſult, after the ſlider is fixed: whereas, by the common method of extracting the ſquare root by A and B direct, the ſlider requires to be moved backwards and forwards by adjuſtment, the eye moving alternately to two points, till ſimilar numbers ſtand, one on B againſt unity on A, and the other on A againſt the ſquare number on B; which ſquare number, in the caſe of finding a mean proportional, muſt be found by a previous operation. Hence, for more convenience in the extraction of roots, and meaſuring of ſolids, an additional line called D has been added to the rule, which renders it more complex, and conſequently ſeldom underſtood by an artificer.

SNOW. See that article (*Encycl.*), where we have endeavoured to account for ſnow's contributing to the preſervation and growth of vegetables. It muſt be confeſſed, however, that if ſnow poſſeſſed only the property of preſerving vegetables, and of preventing them from periſhing by the ſeverity of the cold, it is not at all probable that the ancient philoſophers would have conſidered it as depoſiting on the earth nitrous ſalts, as they might have aſcertained, by a very ſimple experiment,

ment, that it contains none of that salt; for they did not ascribe the same property to rain-water, but they remarked that snow burnt the skin in the manner of acids, as well as other bodies immersed in it. Being induced to conclude that there was nitre in the air, it was natural that they should ascribe to this nitre the burning qualities of snow, and consequently its influence on vegetation.

Such reflections induced Morveau, *alias* Citizen Guyton, to employ J. H. Hassenfratz to inquire into the cause of the difference of the effects of snow and rain-water on various substances. Hassenfratz found that these differences are occasioned by the oxygenation of the snow; and that these effects are to be ascribed to a particular combination of oxygen in this congealed water. He put 1000 grammes of snow in a jar, and 1000 grammes of distilled water in another. He poured into each of the jars an equal quantity of the same solution of turnsole. He placed both the jars in a warm temperature; and after the snow melted, he remarked that the dye was redder in the snow water than in the distilled water. He repeated this experiment, and with the same result. He put into a jar 1000 grammes of distilled water, and into another 1000 grammes of snow. Into each of the jars he put 6·5 grammes of very pure and clean sulphat of iron. In the first, there was precipitated 0·150 grammes of the oxyd of iron, and 0·010 grammes in the other. As the oxyd of iron was precipitated from a solution of the sulphat by oxygen, it thence follows, that the snow contained more oxygen than the distilled water; and it follows, from the first experiment, that this quantity of oxygen was considerable enough to redden the tincture of turnsole.

It is fully demonstrated by these two experiments, that snow is oxygenated water, and that it must consequently have on vegetation an action different from that of common ice. The experiments of Dr Ingenhousz on the germination of seeds have taught us, that the presence and contact of oxygen are absolutely necessary for the plant to expand. They have shewn also, that the more abundant the oxygen is, the more rapidly will the seeds grow. Most plants suffered to attain to their perfect maturity shed on the earth a part of their seed. These seeds, thus abandoned and exposed to the action of cold, are preserved by the snow which covers them, at the same time that they find in the water it produces by melting, a portion of oxygen that has a powerful action on the principle of germination, and determines the seeds that would have perished to grow, to expand, and to augment the number of the plants that cover the surface of the earth.

A very considerable number of the plants which are employed in Europe for the nourishment of men, are sown in the months of September, October, and November. The seeds of several of these germinate before the cold commences its action upon them, and changes the principle of their life. The snow which covers the rest, acting on the germ by its oxygenation, obliges them to expand, and to increase the number of useful plants which the farmer and gardener commit to the earth, and consequently to multiply their productions.

Here, then, we have three effects of snow upon vegetation, all very different, which contribute each separately to increase, every year, the number of our plants, to give them more vigour, and consequently to multiply our crops. These effects are: 1. To prevent the plants from being attacked by the cold, and from being changed or perishing by its force. 2. To furnish vegetables with continual moisture, which helps them to procure those substances necessary for their nutrition, and to preserve them in a strong healthy state. 3. To cause a greater number of seeds to germinate, and consequently to increase the number of our plants.

Snow, Soldering.

SOAP. See Chemistry *Index*, Suppl.

SOLDERING. Under this title, in the *Encyclopædia*, we have given directions for soldering silver, brass, and iron: but there are other metals which must sometimes be soldered; and the following account of different solders, taken from the *Philosophical Magazine*, may be useful to many of our readers.

"When lead, tin, and bismuth, are mixed in a certain proportion, they produce a metal exceedingly fusible, which is known by the name of *soft solder*; but which, from its singular properties, may be applied with advantage to many other useful purposes. Newton, and after him Kraft and Muschenbroek, observed, that five parts of bismuth, three of tin, and two of lead, also five parts of bismuth, four of tin, and one part of lead, melted with a heat of 220 degrees of Fahrenheit; and they found that various mixtures of this kind were fusible by a heat not much greater than that of boiling water. At a later period, V. Rose, a German naturalist, discovered, that a mixture of four parts of bismuth, two of tin, and two of lead, as Kunkel recommended for soldering tin; and D'Arcet, among the French, that a mixture of eight parts of bismuth, three of tin, and five of lead; or eight of bismuth, four of tin, and four of lead; or eight of bismuth, two of tin, and six of lead; also sixteen of bismuth, seven of tin, and nine of lead—all melted, or at least became soft, in boiling water.

"According to the experiments made by Professor Gmelin, respecting the fusion of these three metals, a mixture, consisting of two parts of bismuth, one part of tin, and one of lead, which is the same as Rose proposed, gave a metal that was fused in boiling water. A mixture of six or more parts of bismuth, six of tin, and three of lead, or one part of bismuth, two parts of tin, and two of lead, gave, according to Klein, the solder used by the tin button makers. The same workmen use also for soldering, according to Klein, a mixture of four parts of bismuth, three parts of tin, and five parts of lead. Among the many soft solders employed by the tin-men, a mixture of one part of bismuth, two parts of tin, and one part of lead, is, according to Klein, very much employed. Respecting this kind of solder, the experiments of Professor Gmelin give the following result: One part of bismuth, two parts of tin, and one part of lead, melt in boiling water. According to Klein, the tin-men employ for soldering a mixture of one part of bismuth, twenty four parts of tin, and four parts of lead. Eight parts of bismuth, three of tin, and five of lead, gave a metal exceedingly like tin in its colour and brightness, but very brittle; in water beginning to boil, it became not only soft, but was completely fused. This imitation, however, may be better accomplished by the mixture of Professor Lightenberg, which consists of five parts of bismuth, three

Soldering, Soudan.

three of tin, and two of lead. This metal is very like the former, though not so brittle; but it seemed to melt in hot water even before it came to boil."

As this subject has again come under our notice, it may be proper to lay before our readers what M. Van Braam says of the Chinese method of soldering frying-pans and other vessels of cast-iron, when cracked and full of holes. As the author admits that it *must* appear *impossible* to those who have not *witnessed* the process, such of our artists as have not been in China will give to the tale what credit they think it deserves.

"All the apparatus of the workman consists in a little box, 16 inches long and 6 wide, and 18 inches in depth, divided into two parts. The upper contains three drawers with the necessary ingredients; in the lower is a bellows, which when a fire is wanted is adapted to a furnace eight inches long and four inches wide. The crucibles for melting the small pieces of iron intended to serve as solder are a little larger than the bowl of a common tobacco pipe, and of the same earth of which they are made in Europe: thus the whole business of soldering is executed.

"The workman receives the melted matter out of the crucible upon a piece of *wet paper*, approaches it to one of the holes or cracks in the frying-pan, and applies it there, while his assistant smooths it over by scraping the surface, and afterwards rubs it with a bit of *wet linen*. The number of crucibles which have been deemed necessary are thus successively applied, in order to stop up all the holes with the melted iron, which consolidates and [illegible] with the broken utensil, and which [illegible]. The furnace which our author [illegible] certain [illegible] go- [illegible] of [illegible]ing [illegible] fre- [illegible] George Staunton.

SOUDAN, [illegible] ne- [illegible] the name of [illegible] DAR-FUR. We [illegible] by any [illegible] Mr Browne, who [illegible] between the 13th and 16th degrees of north latitude, and between the 26th and 30th degrees of east longitude. These numbers are not exact; it does not reach so far east as the 30th degree, nor so far north as the 16th; but on his map minutes are not marked. On the north, it is bounded by a desert which separates it from Egypt; on the east, by Kordofan, which is now subject to Soudan, and lies between it and Sennaar; and on the south and east, by countries of which the names are hardly known. Mr Browne was induced to visit Soudan in hopes of being able to trace the Bahr-el-abiad, or true Nile, to its source: but he was disappointed; for that river rises in mountains considerably farther south than the limits of this kingdom; and the Sultan, a cruel and capricious tyrant, detained him a prisoner at large almost three years.

Soudan, or Dar-fur, abounds with towns or villages, ill built, of clay, and none of them very large. Of these it is not worth while to give an account. Its seasons are divided into rainy and dry. The perennial rains, which fall in Dar-Fur from the middle of June till the middle of September in greater or less quantity, but generally both frequent and violent, suddenly invest the face of the country, till then dry and steril, with a delightful verdure. Except where the rocky nature of the soil absolutely impedes vegetation, wood is found in great quantity; nor are the natives assiduous completely to clear the ground, even where it is designed for the cultivation of grain. As soon as the rains begin, the proprietor, and all the assistants that he can collect, go out to the field; and having made holes at about two feet distance from each other, with a kind of hoe, over all the ground he occupies, the *dokn*, a kind of millet, is thrown into them, and covered with the foot, for their husbandry requires not many instruments. The time for sowing the wheat is nearly the same. The *dokn* remains scarcely two months before it is ripe; the wheat about three.

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The animals in Soudan, both wild and tame, are the same as in other parts of Africa in the same latitude. Though the Furians breed horses, and purchase very fine ones in Dongola, and from the Arabs to the east of the Nile, the ass is more used for riding; and an Egyptian ass (for the asses of Dar-Fur are diminutive and indocile like those of Britain) fetches from the value of one to that of three slaves. The villages of this country, like those of Abyssinia, are infested with hyenas; and in the unfrequented parts of the country are the elephant, the rhinoceros, the lion, the leopard, and all the other quadrupeds of Africa. The Arabs often eat the flesh of the lion and the leopard; and sometimes they so completely tame those animals, as to carry them loose into the market place. Our author tamed two lions, of which one acquired most of the habits of a dog. He satiated himself twice a week with the offal of the butchers, and then commonly slept for several hours successively. When food was given them, they both grew ferocious towards each other, and towards any one who approached them. Except at that time, though both were males, he never saw them disagree, nor shew any sign of ferocity towards the human race. Even lambs passed them unmolested.

Among the birds, the *vultur perenopterus*, or white-headed vulture, is most worthy of notice. It is of surprising strength, and is said by the natives to be very long-lived, *sed fides penes auctores*. "I have lodged (says Mr Browne) a complete charge of large shot, at about 50 yards distance, in the body of this bird: it seemed to have no effect on him, as he flew to a considerable distance, and continued walking afterwards. I then discharged the second barrel, which was loaded with ball: this broke his wing; but on my advancing to seize him, he fought with great fury with the other. There are many thousands of them in the inhabited district. They divide the field with the hyena: what carrion the latter leaves at night, the former come in crowds to feed on in the day. Near the extremity of each wing is a horny substance, not unlike the spur of an old cock. It is strong and sharp, and a formidable instrument of attack. Some fluid exudes from this bird that smells like musk; but from what part of him I am uncertain." The serpents found in Soudan are the same as in Egypt; but the natives have not the art of charming them, like the Egyptians. The locust of Arabia is very common, and is frequently roasted and eaten, particularly by the slaves.

In Dar-Fur there seems to be a scarcity of metals; but

Soudan. but in its neighbourhood to the south and west all kinds are to be found. The copper brought by the merchants from the territories of certain idolatrous tribes bordering on Fur, is of the finest quality, in colour resembling that of China, and appears to contain a portion of zinc, being of the same pale hue. Iron is found in abundance; but they have not yet learned the art of converting it into steel. Silver, lead, and tin, our author never heard mentioned in Soudan, but as coming from Egypt; but of gold, in the countries to the east and west, the supply is abundant. Alabaster, and various kinds of marble, are found within the limits of Fur, as is fossil salt within a certain district; and there is a sufficient supply of nitre, of which, however, no use is made.

The restraint under which Mr Browne was kept in this inhospitable country, prevented him from making a full catalogue of its vegetable productions. Of the trees which shade our forests or adorn our gardens in Europe, very few exist in Dar-Fur. The characteristic marks of those species which most abound there, are their sharp thorns, and the solid and unperishable quality of their substance. They seem to be much the same as those which Bruce found in Abyssinia. There is a small tree called *enneb*, to the fruit of which they have given the name of grapes. It bears leaves of light green hue; and the fruit, which is of a purple colour, is attached, not in bunches, but singly to the smaller branches, and interspersed among the leaves. The internal structure of the fruit is not very unlike the grape, which it also resembles in size: but the pulp is of a red hue, and the taste is strongly astringent. The water-melon (*cucurbita citrulius*) grows wild over almost all the cultivable lands, and ripens as the corn is removed. In this state it does not attain a large size. The inside is of a pale hue, and has little flavour. As it ripens, the camels, asses, &c. are turned to feed on it, and it is said to fatten them. The seeds, as they grow blackish, are collected to make a kind of tar, *kutran*. Those plants of the melon which receive artificial culture grow to a large size, and are of exquisite flavour. Tobacco is produced in abundance; and our author speaks of cochineal as found in Dar-Fur, or some of the neighbouring countries.

The harvest is conducted in a very simple manner. The women and slaves of the proprietor are employed to break off the ears with their hands, leaving the straw standing, which is afterwards applied to buildings and various other useful purposes. They then accumulate them in baskets, and carry them away on their heads. When thrashed, which is aukwardly and incompletely performed, they expose the grain to the sun till it become quite dry; after this a hole in the earth is prepared, the bottom and sides of which are covered with chaff to exclude the vermin. This cavity or magazine is filled with grain, which is then covered with chaff, and afterwards with earth. In this way the maize is preserved tolerably well. In using it for food, they grind it, and boil it in the form of polenta, which is eaten either with fresh or sour milk, or still more frequently with a sauce made of dried meat pounded in a mortar, and boiled with onions, &c. The Furians use little butter; with the Egyptians and Arabs it is an article in great request. There is also another sauce which the poorer people use and highly relish; it is composed of an herb called *cowel* or *cawel*, of a taste in part acescent and in part bitter, and generally disagreeable to strangers. Soudan.

The magistracy of one, which seems tacitly, if it be not expressly, favoured by the dispensation of Mohammed, as in most other countries professing that religion, prevails in Dar-Fur. The monarch indeed can do nothing contrary to the Koran, but he may do more than the laws established thereon will authorise; and as there is no council to controul or even to assist him, his power may well be termed despotic. He speaks in public of the soil and its productions as his personal property, and of the people as little else than his slaves.

His power in the provinces is delegated to officers, who possess an authority equally arbitrary. In those districts, which have always, or for a long time, formed an integral part of the empire, these officers are generally called *Meleks*. In such as have been lately conquered, or, perhaps more properly, have been annexed to the dominion of the Sultan under certain stipulations, the chief is suffered to retain the title of Sultan, yet is tributary to and receives his appointment from the Sultan of Fur.

Despotic and arbitrary as he is, the Sultan here does not seem wholly inattentive to that important object, agriculture. Nevertheless, it may be esteemed rather a blind compliance with ancient custom, than individual public spirit, in which has originated a practice adopted by him, in itself sufficiently laudable, since other of his regulations by no means conduce to the same end. At the beginning of [illegible] wet season, which is also the moment for sowing the corn, the king goes out with his Meleks, and [illegible] and while the people are employed [illegible] ground and sowing the seed, he [illegible] several holes with his own hand. The same custom, it is said, obtains in Bornou and other countries in this part of Africa. It calls to the mind a practice of the Egyptian kings mentioned by Herodotus.

The population of Dar-Fur is not large. An army of 2000 men was spoken of, when Mr Browne was in the country, as a great one; and he does not think that the number of souls within the empire can much exceed 200,000. The troops of this country are not famed for skill, courage, or perseverance. In their campaigns, much reliance is placed on the Arabs who accompany them, and who are properly tributaries rather than subjects of the Sultan. One energy of barbarism they indeed possess in common with other savages, that of being able to endure hunger and thirst; but in this particular they have no advantage over their neighbours. In their persons the Furians are not remarkable for cleanliness. Though observing as Mahommedans all the superstitious formalities of prayer, their hair is rarely combed, or their bodies completely washed. The hair of the pubes and axillæ it is usual to exterminate; but they know not the use of soap; so that with them polishing the skin with unguents holds the place of perfect ablutions and real purity. A kind of farinaceous paste is however prepared, which being applied with butter to the skin, and rubbed continually till it become dry, not only improves its appearance, but removes from it accidental sordes, and still more the effect of continued transpiration, which, as there are no baths in the country, is a consideration of some importance.

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ance. The female slaves are dexterous in the application of it; and to undergo this operation is one of the refinements of African sensuality.

Nothing resembling current coin is found in Soudan, unless it be certain small tin rings, the value of which is in some degree arbitrary. The Austrian dollars, and other silver coins brought from Egypt, are all sold as ornaments for the women.

The disposition of the Furians is cheerful; and that gravity and reserve which the precepts of Mahommedism inspire, and the practice of the greater number of its professors countenances and even requires, seems by no means as yet to sit easy on them. A government perfectly despotic, and not ill administered, as far as relates to the manners of the people, yet forms no adequate restraint to their violent passions. Prone to inebriation, but unprovided with materials or ingenuity to prepare any other fermented liquor than *buza*, with this alone their convivial excesses are committed. But though the Sultan published an ordnance (March 1795), forbidding the use of that liquor under pain of death, the plurality, though less publicly than before, still indulge themselves in it. A company often sits from sunrise to sun-set, drinking and conversing, till a single man sometimes carries off near two gallons of that liquor. The buza has, however, a diuretic and diaphoretic tendency, which precludes any danger from these excesses. In this country dancing is practised by the men as well as the women, and they often dance promiscuously.

The vices of thieving, lying, and cheating in bargains, with all others [illegible] allied to them, [illegible] under the same circumstances, [illegible]. No property, whether [illegible] out of the sight of the owner, [illegible] it, unless he be [illegible] selling, the pa- [illegible] for the pa- [illegible] [illegible] to the [illegible] false- [illegible]

The privilege of polygamy, which, as is well known, belongs to their religion, the people of Soudan push to the extreme. By their law, they are allowed four free women, and as many slaves as they can maintain; but the Furians take both free women and slaves without limitation. The Sultan has more than a hundred free women, and many of the Meleks have from twenty to thirty. In their indulgence with women, they pay little regard to restraint or decency. The form of the houses secures no great secrecy to what is carried on within them; yet even the concealment which is thus offered is not always sought. The shade of a tree, or long grass, is the sole temple required for the sacrifices to the Cyprian goddess. In the course of licentious indulgence, father and daughter, son and mother, are sometimes mingled; and the relations of brother and sister are exchanged for closer intercourse.

Previously to the establishment of Islamism * and kingship, the people of Fur seem to have formed wandering tribes; in which state many of the neighbouring nations to this day remain. In their persons they differ from the negroes of the coast of Guinea. Their hair is generally short and woolly, though some are seen with it of the length of eight or ten inches, which they esteem a beauty. Their complexion is for the most part perfectly black. The Arabs, who are numerous within the empire, retain their distinction of feature, colour, and language. They most commonly intermarry with each other. The slaves, which are brought from the country they call *Fertit* (land of idolaters), perfectly resemble those of Guinea, and their language is peculiar to themselves.

Soudan; Souffriere.

The revenues of the crown consist of a duty on all merchandise imported, which, in many instances, amounts to near a tenth; of a tax on all slaves exported to Egypt; of all forfeitures for misdemeanors; of a tenth on all merchandise, especially slaves, brought from every quarter but Egypt, and when slaves are procured by force, this tenth is raised to a fifth; of a tribute paid by the Arabs, who breed oxen, horses, camels, sheep; of a certain quantity of corn paid annually by every village; besides many valuable presents, which must be paid by the principal people, both at stated times and on particular occasions. Add to all this, that the king is chief merchant in the country; and not only dispatches with every caravan to Egypt a great quantity of his own merchandise, but also employs his slaves and dependents to trade with the goods of Egypt on his own account, in the countries adjacent to Soudan.

The commodities brought by the caravans from Egypt are, 1. Amber beads. 2. Tin, in small bars. 3. Coral beads. 4. Cornelian beads. 5. False cornelian beads. 6. Beads of Venice. 7. Agate. 8. Rings, silver and brass, for the ancles and wrists. 9. Carpets, small. 10. Blue cotton cloths of Egyptian fabric. 11. White cotton ditto. 12. Indian muslins and cottons. 13. Blue and white cloths of Egypt, called *Melayes*. 14. Sword-blades, strait (German), from Cairo. 15. Small looking-glasses. 16. Copper face-pieces, or defensive armour for the horses heads. 17. Fire arms. 18. Kohhel for the eyes. 19. Rhea, a kind of moss from European Turkey, for food and a scent. 20. *She*, a species of absynthium, for its odour, and as a remedy: both the last sell to advantage. 21. Coffee. 22. *Mahleb*, *Krumphille*, *Symlille*, *Sandal*, nutmegs. 23. *Dufr*, the shell of a kind of fish in the Red Sea, used for a perfume. 24. Silk unwrought. 25. Wire, brass and iron. 26. Coarse glass beads, made at Jerusalem, called *hersh* and *munjur*. 27. Copper culinary utensils, for which the demand is small. 28. Old copper for melting and reworking. 29. Small red caps of Barbary. 30. Thread linens of Egypt—small consumption. 31. Light French cloths, made into benishes. 32. Silks of Scio, made up. 33. Silk and cotton pieces of Aleppo, Damascus, &c. 34. Shoes of red leather. 35. Black pepper. 36. Writing paper (*papier des trois lunes*), a considerable article. 37. Soap of Syria.

The goods transported to Egypt are, 1. Slaves, male and female. 2. Camels. 3. Ivory. 4. Horns of the rhinoceros. 5. Teeth of the hippopotamus. 6. Ostrich feathers. 7. Whips of the hippopotamus's hide. 8. Gum. 9. Pimento. 10. Tamarinds, made into round cakes. 11. Leather sacks for water (*ray*) and dry articles (*geraub*). 12. Peroquets in abundance, and some monkeys and Guinea fowls. 13. Copper, white, in small quantity.

SOUFFRIERE, a small town, situated at the bottom of a bay, towards the leeward extremity of the island of St Lucia. There is nothing in the town itself which

could

Souffriere, Sound.

could have entitled it to notice in this work; but the ground about it is very remarkable. It has been described by different authors; and our readers will probably not be ill pleased with the following description of this wonderful spot by Dr Rollo.

"Souffriere (says he) is surrounded by hills covered with trees, the declivities of which, and every part capable of produce, are cultivated, and afford good sugar-cane. This place has its marshes, but not so extensive, or so much to windward as those about Carenage.

"The extremity of the south side of Souffriere Bay runs into two steep hills of a conical figure, which are nearly perpendicular: they are reckoned the highest on the island, and are known by the name of the *Sugar-Loaf Hills*. From their height and straitness it is impossible to ascend them: we were told it was once attempted by two negroes, but they never returned. They are covered with trees and shrubs, and are the shelter of goats, several of which sometimes descend, and are shot by the natives.

"After you pass the hills to windward of Souffriere, a fine clear and level country presents itself. From the back of the Sugar Loaf Hills, and all along the sea-coast, to the distance, we suppose, of from fifteen to twenty miles, this flat or level extends: it is all cultivated and divided into rich estates, affording sugar-cane equal to any in our islands. This beautiful spot is intersected by many rivers of very clear water, and these are conducted by art to the purpose of sugar making. The rains in this part are less frequent than on any other part of the island; however, they have often a proportion more than sufficient. The wind here blows from the sea, or nearly so.

"We cannot finish this description without taking notice of a volcano in the neighbourhood of Souffriere. You pass over one or two small hills to the southward of the town, and before any mark of the place is perceived you are sensible of the smell of sulphur. The first thing you discern is a rivulet of black running water, sending forth steams as if nearly boiling. From the prospect of this you soon open on the volcano, which appears in a hollow, surrounded close on every side by hills. There are only two openings; the one we entered, and another almost opposite to it on the north side. In the hollow there are many pits of a black and thick boiling matter, which seems to work with great force. Lava is slowly thrown out; and in the centre of the hollow there is a large mass of it, forming a kind of hill. This we ascended; but were soon obliged to return from the excessive heat. The lava is a sulphur mixed with a calcareous earth and some saline body. We found small quantities of alum in a perfect state. In the opening, at the north side of the hollow, there is a rivulet of very good water. On stirring the bottom, over which this water runs, we were surprised with feeling it very hot; and on placing a tumbler filled with some of the water close to the bottom of the rivulet, it soon became so hot as not to be touched. The liquid which runs from the pits is strongly impregnated with sulphur, and resembles a good deal the preparation sold in the shops, known by the name of *aqua sulphurata*, or *gas sulphuris*."

SOUND-BOARD, the principal part of an organ, and that which makes the whole machine play. This sound-board, or summer, is a reservoir into which the wind, drawn in by the bellows, is conducted by a port-vent, and thence distributed into the pipes placed over the holes of its upper part. This wind enters them by valves, which open by pressing upon the stops or keys, after drawing the registers, which prevent the air from going into any of the other pipes beside those it is required in.

Sound. ‖ Spallanzani.

Sound Board denotes also a thin broad board placed over the head of a public speaker, to enlarge and extend or strengthen his voice.

Sound-boards, in theatres, are found by experience to be of no service; their distance from the speaker being too great to be impressed with sufficient force. But sound boards immediately over a pulpit have often a good effect, when the case is made of a just thickness, and according to certain principles.

Sound-Post, is a post placed withinside of a violin, &c. as a prop between the back and the belly of the instrument, and nearly under the bridge.

SOWAL, in the language of Bengal, a question or request.

SPALLANZANI (Lazarus), was born at Scandiano, in the dutchy of Modena, on the 10th of January 1729. He was son of Jean Nicholas Spallanzani, an esteemed jurisconsult, and of Lucia Zugliani. He commenced his studies in his own country, and at the age of fifteen years went to Reggio de Modena in order to continue them. The Jesuits, who instructed him in the belles lettres, and the Dominicans, who heard of his progress, were ea[illegible] attaching him to them; but his pass[illegible] extending his knowledge led him to Bologna, where [illegible] Laura Bassi, a woman justly celebrated for [illegible] and her skill in natural philosophy [illegible] was one of the most illustrious [illegible] of the Institute and of Italy. [illegible] he learned to prefer [illegible] commentators, and to judge of the value of the commentary by its resemblance to the original. He instantly availed himself of the wisdom of that lady's counsels, and was not [illegible] before he experienced the happy effects of it. How agreeable it is to see him in 1765 painting his gratitude for his instructor, to whom he dedicated a Latin dissertation at that time, in which he mentions the applause that Laura Bassi received at Modena, when she entered the auditory of her pupil, then become professor. The taste of Spallanzani for philosophy was not exclusive; he already thought, like all great men, that the study of antiquity and the belles lettres was requisite to give to ideas that clearness, to expressions that accuracy, and to reasonings that connection, without which the finest thoughts become barren. He studied his own language with care, and perfected himself in the Latin tongue; but above all, he attached himself to the Greek and the French. Homer, Demosthenes, St Basil, were his favourite authors. Spallanzani applied himself to jurisprudence at the instance of a father whom he tenderly loved: he was upon the point of receiving the degree of doctor of civil law, when Anthony Vallisneri, professor of natural history at Padua, persuaded him to renounce this vocation, by promising to obtain the consent of his father, who was sensibly touched by his son's devotion to his will, and who thereby left him at liberty to follow his own inclinations. From that moment he gave himself

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up with more ardour than ever to the study of mathematics, continuing that also of the living and dead languages.

Spallanzani was presently known all over Italy, and his own country was the first to do homage to his talents The university of Reggio, in 1754, chose him to be professor in logic, metaphysics, and Greek. He taught there for ten years; and during that period consecrated all the time he could spare from his lessons to the observation of Nature. Now and then an accidental discovery would increase his passion for natural history, which always augmented by new successes. His observations upon the animalculæ of infusions fixed the attention of Haller and of Bonnet; the latter of whom assisted him in his glorious career, and thenceforth distinguished him as one of the learned interpreters of Nature.

In 1760 Spallanzani was called to the university of Modena; and although his interest would have made him accept the advantageous offers of the university of Coimbra, of Parma, and of Cesena; yet his patriotism and his attachment to his family confined his services to his own country. The same considerations engaged him to refuse the propositions made him by the academy of Petersburg some years after. He remained at Modena till the year 1768, and he saw raised by his care a generation of men constituting at this time the glory of Italy. Among them may be counted *Venturi*, professor of natural philosophy at Modena; *Belloni*, bishop of Carpi; *Lucchesini*, ambassador of the late king of Prussia; and the poet *Angelo Mazza* of Parma.

During his [illegible] Modena, Spallanzani published in [illegible] *Microscopiche concernenti il* [illegible]. He therein established [illegible] called, but not generally [illegible] *microscopic animalcula*, by the most ingenious, and at the same time solid, experiments. He sent this work to Bonnet, who formed his opinion of the author accordingly, and who lived to see the accomplishment of the prophecy he drew from it. From that moment the most intimate acquaintance was formed between them, and it lasted during their lives, of which it constituted the chief happiness. In the same year Spallanzani published a dissertation truly original; *De Lapidibus ab Aqua resilientibus*. In that work he proves, by satisfactory experiments, contrary to the commonly received opinion, that the ducks and drakes (as they are called) are not produced by the elasticity of the water, but by the natural effect of the change of direction which the stone experiences in its movement, after the water has been struck by it, and that it has been carried over the bend or hollow of the cup formed by the concussion.

In 1768 he prepared the philosophers for the surprising discoveries he was about to offer them throughout his life, in publishing his *Prodromo di un Opera da Imprimersi sopra le Riproduzioni Animali*. He therein lays down the plan of a work which he was anxious to get up on this important subject; but this simple prospectus contains more real knowledge than all the books which had appeared, because it taught the method that ought to be followed in this dark research, and contained many unexpected facts; such as the pre-existence of tadpoles at the fecundation, in many species of toads and frogs; the reproduction of the head cut off from snails, which he had already communicated to Bonnet in 1766, and which was disputed for some time, in spite of the repeated confirmation of this phenomenon by Herissant and Lavoisier. He demonstrated it again afterwards in the *Memorie della Societa Italiana*; as also the renewal of the tail, the limbs, and even the jaws, taken from the aquatic salamander. These facts continue to astonish even at this day, when they are thought of, notwithstanding every one has had the opportunity of familiarising himself with them: and we hardly know which we ought most to admire, the expertness of Spallanzani in affording such decisive proofs, or his boldness in searching after them, and seizing them. We have to regret, that the project of his great undertaking is not realized; but various circumstances prevented him from giving way to the solicitations of his friends for its accomplishment. Perhaps he despaired of throwing upon every part of it all the light which at first he thought he might be able; and found it prudent to mature his ideas by new meditations: this may probably have been as powerful a cause as that other calls and occupations, perpetually accumulating, should not have allowed him to pursue it as he had intended. He has always laid Nature open to full view; and the thinnest veil darkened her till he succeeded in removing it altogether.

The physiology of Haller that Spallanzani studied fixed his attention upon the circulation of the blood, in which he discovered several remarkable phenomena. He published, in 1768, a small tract: *Dell' Azione del Cuore ne' Vasi Sanguigni nuovi Osservazioni*, and he reprinted it in 1773, with three new dissertations, *De' Fenomeni della Circolazione osservata nel' Giro universali de' Vasi; De' Fenomeni della Circolazione Languente; De' Moti del Sangue, independente del Azione del Cuore e del Pulsare delle Arterie*. This work, but little known, contains a series of observations and experiments, of the most ingenious and delicate nature, upon a subject of which the surface only is known. It merits the attention of those who are interested in the progress of physiology.

When the university of Padua was re-established upon a larger scale, the Empress Maria Theresa directed the Count de Firmian to invite him to fill a chair, as professor of natural history; his great reputation rendered him eligible for this distinction, solicited by many celebrated men, and he merited it by his success, and by the crowd of students who thronged to his lessons. Only great men make excellent masters, because their ideas are the most perspicuous, the most extensive, and best connected.

Spallanzani united a vast extent of knowledge to a fine genius; a method simple, but rigorous in its nature; and he connected what he knew to principles firmly established. His ardent love of truth made him discuss, with the utmost care, the theories which prevailed; to sound their solidity, and discover their weak sides. The great art which he had acquired, of interpreting Nature by herself, diffused such a light over his lessons, as made every thing perspicuous that was capable of affording instruction. An eloquence at once plain and lively animated his discourse; the purity and elegance of his style charmed all who heard it: in short, it was known that he always occupied himself about

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the means of rendering his lessons useful, which he prepared a year beforehand. They became always new and engaging, by his new observations, and by the enlarged views that his meditations presented to him. The learned persons who attended his lectures were pleased to become his scholars, in order to know better what they already knew, and to learn that which otherwise they would perhaps never have known.

In arriving at the university, Spallanzani took the *Contemplation de la Nature* of Bonnet for the text of his lessons: he filled up the vacancies in it, he unfolded the ideas, and confirmed the theories by his experiments. He believed, with reason, that the book which inspired him with the love of natural history by reading it, was the most proper to give birth to it in the minds of his disciples.

He translated it into Italian, and enriched it with notes; he added a preface to it, wherein he pointed out the subjects of the vegetable and animal economy, which in an especial manner deserved the attention of his pupils; and sometimes pointing out to them the means of succeeding in their researches. It was thus he at first devoted himself to the pleasing employment of instructor of his countrymen, and that he became the model of those who were desirous of instructing usefully. He published the first volume of his translation in 1769, and the second in 1770.

The connection of Spallanzani with Bonnet had an influence upon his genius, which bent to the severe method of the philosopher of Geneva. He prided himself in being his pupil, and he unceasingly meditated upon his admirable writings; and thus it was that he became desirous of seeking in Nature for the proofs of Bonnet's opinion upon the generation of organized bodies, and that this charming subject fixed his attention for a long time.

He published, in 1776, the two first volumes of his *Opuscoli di Fisica Animale e Vegetabile*: they are the explanation of a part of the microscopic observations which had already appeared.

If the art to observe be the most difficult, it is nevertheless the most necessary of all the arts; but it supposes every quality, every talent: and further, though each believes himself more or less consummate therein, yet it is obvious, that only great men have exercised it in a distinguished manner. Genius alone fixes the objects worthy of regard; that alone directs the senses to the obscurities which it is necessary to dissipate; it watches over them to prevent error; it animates them to follow by the scent, as it were, that which they have but a distant view of: it takes off the veil which covers what we are looking after; it supports the patience which waits the moment for gratifying the sight in the midst of obstacles multiplying one upon another: in short, it is genius that concentrates the attention upon an object, which communicates that energy to him for imagining, that sagacity for discovering, that promptness for perceiving, without which we see only one side of truth, when we do not happen to let it escape altogether. But this is not all; for after Nature has been read with precision, it is necessary to interpret her with fidelity; to analyse by the thought the phenomena anatomised by the senses; to consider of the species by observing the individual, and to anticipate the general propositions by considering the unconnected facts. Here prudence and circumspection will not always secure us against error, if an ardent love for the truth does not allay observations and their consequences in its crucible, and thereby reduce every thing to *scoriæ* which is not truth. Spallanzani.

Such was Spallanzani in all his researches; such we see him in all his writings. Occupied by the great phenomenon of generation, he examined the opinion of Needham to demonstrate its want of foundation. The latter, not satisfied with the microscopic observations of Spallanzani, which weakened the imagined vegetative force to put the matter in motion, challenged the professor of Reggio to a reperusal of what he had written; but he proved to the other, that we in common practice always see that which has been *well observed*, but that we never again see that which we have been contented with *imagining we saw*.

Spallanzani has received much praise for the politeness with which he carried on this controversy, and for the severe logic with which he demonstrates to Needham the causes of his error; and proves, that the animalculæ of infusions are produced by germs; that there are some of them which defy, like certain eggs and seeds, the most excessive cold, as well as the heat of boiling water. On this occasion, he treats on the influence of cold upon animals, and proves that the lethargic numbness of some, during winter, does not depend upon the impression the blood may receive from it; since a frog, deprived of his blood, becomes lethargic when he is reduced to the same cold state by an immersion in ice, and swims as before when restored to warmth. In the same manner he shews that odours, various liquors, the [illegible] act upon animalculæ as upon other animals; that they are [illegible] viviparous, and hermaphrodite. Thus [illegible] over these distant regions of Nature with [illegible] we are always meeting with new facts, profound remarks, precious details, and some curious anecdotes; in short, an universal history of these beings which are the most numerous of the globe, although their existence is scarcely suspected, and whose organization is in many respects different from that of known animals.

The second volume of this work is a new voyage into the most unknown parts; a sublime pencil had already painted it, but the picture was not done after Nature. Spallanzani here gives a history of the spermatic animalcule, which the eloquent historian above alluded to always confounds with the animalculæ of infusions. We cannot but admire the modest diffidence of this new demonstrator, struggling against his own opinion and the authority of Buffon; and he appears to admit, with repugnance, the results of his multiplied, and in a thousand ways varied, observations, which expose the feebleness of the system of organic moleculæ.

Spallanzani afterwards describes the volvox and the slow-moving animalculæ (*rotifère* and *tardigrade*), those colossuses of the microscopic world, so singular by their figure and organization, but more singular still by their faculty of resuming life, after a total suspence of all the apparent acts of it during many years.

We will not here speak of the experiments of Spallanzani on the death of animals in close vessels, because he took up the subject again, and enlarged and exemplified it by the new lights of chemistry; but this collection

lection he concludes with another on the history of vegetable mould growing on the surface of liquors and moist substances, the seeds of which he shews to float in the air; and he remarks, that these microscopic champignons or mushrooms distinguish themselves from other plants by their tendency to grow in all directions, without conforming to the almost universal law of perpendicularity of stalk to the ground.

Spallanzani was placed at the head of the university's cabinet of natural history, but he was little more than titular depositary of a treasure which no longer existed. He laid the foundations, however, for its renewal, and by his care it is become one of the most precious and useful. He enriched it through his repeated travels by land and sea, in Europe, in Asia, across the Apennines, the Alps, the Krapacks, at the bottom of mines, on the top of volcanoes, at the mouth of craters: supported by his ardent passion in the midst of perils, he preserved the *sang-froid* of the philosopher to contemplate these wonders, and the piercing eye of an observer to study them. It is thus that he always distinguished the proper objects for improving science by favouring instruction; it is thus that he filled this depositary with treasures, that all the gold in the world could not have obtained, because gold never supplies the genius and the discernment of the enlightened naturalist.

In 1779 Spallanzani ran over Switzerland and the Grisons; he then went to Geneva, where he spent a month with his friends, who admired him the more in his conversations after having admired him in his writings. He then returned to Pavia, and published, in 1780, two new volumes of his *Dissertazioni di Fisica Animale e Vegetabile*. He therein reveals the secrets of [illegible] obscure phenomena, concerning the [illegible] economy.

[illegible] upon *digestion* [illegible] to study this dark operation, he repeated [illegible] experiments upon the gallinaceous [illegible] the trituration, which [illegible] could not, however, [illegible] that the gizzard of these birds [illegible] of fruit to pieces, as if done [illegible] sharp-pointed instruments, [illegible] powder so formed; that it was [illegible] should undergo a new operation in the stomach before it could become fit chyle for affording the elements of the blood and other humours. He established the point, that the digestion was performed in the stomach of numerous animals by the powerful action of a juice which dissolves the aliments; and to render his demonstration the more convincing, he had the courage to make several experiments on himself which might have proved fatal, and had the address to complete his proofs by artificial digestions made in glasses upon the table, by mixing the chewed aliments with the gastric juice of animals, which he knew how to extract from their stomachs. But this book, so original by the multitude of experiments and curious observations which it contains, is still more worthy of attention by the philosophic spirit which detected it.

This subject is one of the most difficult in physiology: the observer is always compelled to act and to look with darkness around him; he is obliged to manage the animal with care, to avoid the derangement of his operations; and when he has laboriously completed his experiments, it is necessary that he should well distinguish the consequences, sometimes erroneous, which may be drawn from those of observation, which never deceive when they are immediate. Spallanzani, in this work, is truly a fine spectacle; scrupulously analysing the facts in order to discover their causes with certainty; inventing happy resources for surmounting the obstacles which renew themselves; comparing Nature with his experiments, to judge of them; catching hold in his observations of every thing that is essential in them; measuring their solidity by the augmentation or diminution of supposed causes; drawing the best-founded conclusions, and rejecting the most plausible hypotheses; modestly exposing the errors of those who have gone before him, and employing analogy with that wise circumspection which inspires confidence in an instrument at once so dangerous and so useful. But let it be known, Spallanzani had a capacity in particular for discovering the truth, while the greater part of observators scarcely ever attain it; and then, after having described around them a circuitous trace, he runs upon it by a straight line, and possesses himself of it so as that it cannot escape him.

This work put John Hunter out of humour; and he published, in 1785, *Some Observations upon Digestion*, wherein he threw out some bitter sarcasms against Spallanzani; who took ample revenge by publishing this work in Italian, and addressing to *Caldani*, in 1788, *Una Lettera Apologetica in Risposta alle Osservazione del Signor Giovanni Hunter*. He exposes, with moderation, but with an irresistible logic, the oversights of the English physiologist, and points out his errors in a manner which left him no hope of a reply.

The second volume treats of the generation of animals and plants. Spallanzani proves, by experiments as satisfactory as they are surprising, the pre-existence of germs to fecundation; he shews the existence of tadpoles in the females of five different species of frogs, in toads, and in salamanders, before their fecundation: he recounts the success of some artificial fecundations upon the tadpoles of those five species, and even upon a quadruped. He in the same manner shews the seed in the flowers, before the emission of their farina; and by a subtle anatomy of which one can hardly form an idea, he exhibits to the eye in the flower of the *spartium junceum*, the filiqua, its seeds, with their lobes, and the embryo plant; he pursues them in their expansion before and after fecundation, and leaves not a doubt but that the seeds and the pericarpia existed long before the blossoming of the buds, and consequently a long time before they could have been fecundated. He has repeated these observations upon various species of plants with the same results; in short, he has raised the individuals of plants with female flowers which have borne fecundated seeds, although they were out of the reach even of suspicion of a communication with the farina of the male flowers. Such is the series of surprising phenomena Spallanzani adds to the history of Nature.

According to custom, he availed himself of the academical vacation of 1781, to make a journey, the object of which was to add to the cabinet of Pavia. He set out in the month of July for Marseilles, where he commenced a new history of the sea, which had presented him with a crowd of novel and curious facts upon

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on numerous genera of the inhabitants of the ocean. He went likewise to Finale, to Genoa, to Massa, and to Carrara, to observe the quarries of marble so famous with the statuaries; he returned to Spezzia, and thence brought to Pavia an immense harvest of fishes, crustaceous and testaceous, which he deposited in that cabinet of which his voyages and travels had rendered him so worthy to be the guardian. He visited, in the same view, and with the same success, the coasts of Istria in 1782; the Apennine Mountains in 1783, where he noticed the terrible hurricanes, and the surprising vapours which rendered that year so famous in meteorology. The cabinet of Pavia thus every year saw its riches increase; and in the same proportion it became the object of strangers admiration; but every one admired still more the immense labour of Spallanzani, who had collected every part of it.

The Emperor Joseph knew this when he came into Lombardy: he desired to have a conversation with Spallanzani; and his majesty expressed his approbation by presenting him with his medal in gold.

The university of Padua offered to Spallanzani, in 1785, the chair of natural history, which the death of Anthony Vallisneri had left vacant, promising him more considerable advantages than those which he enjoyed at Pavia; but the archduke doubled his pension, and allowed him to accompany to Constantinople the Chevalier Zuliani, who had just been nominated ambassador from the republic of Venice.

He left this city the 21st of August; and during his voyage made several observations upon the marine productions he met with in those climates, as well as upon the meteorological events of every day, among which he had the advantage of beholding a species of water-spout. He touched at several islands in the Archipelago, which he examined, and went ashore at Troy to visit the places sung by the poet whom he preferred to all others; and in treading upon that ground so anciently famous, he made some geological observations truly original. One may judge before hand of the interest we shall feel in reading the Voyage of Spallanzani, by some memoirs which have appeared in the *Memorie della Societa Italiana* upon the water-spouts at sea, the stroke of the torpedo, divers marine productions, and the island of Cytherea, where he discovered a mountain composed of various species of fossils. Spallanzani arrived at Constantinople the 11th of October, and remained there eleven months: he must have been greatly out of his element in that country of ignorance and superstition, if he had not had Nature to study, and Zuliani to hear him. The physical and moral phenomena of this country, quite new to him, fixed his attention; he strayed over the borders of the two seas, and climbed up the neighbouring hills; he visited the island of Chalki, where he made known to the Turks a mine of copper, the existence of which they never so much as suspected. He went to the Principi island, a few miles distant from Constantinople, where he discovered an iron mine equally unthought of by the Turks. He returned to Europe loaded with spoils from the East, composed of the creatures of the three kingdoms, peculiar to those regions: after having been useful to the Orientals, who were incapable of appreciating his merit, or rather of imagining he could have any, he set out on his return for Italy the 16th of August, 1786.

A voyage by sea was in every respect the most safe and the most commodious; but Spallanzani considered the dangers and the inconveniences of the road as nothing when employed in any beneficial pursuit; he braved all the perils of those desert regions, where there is no police, no security. When he arrived at Bucharest, he was retained there during nine days by the celebrated and unhappy Mauroceni, hospodar of Wallachia. This prince, the friend of science, received him with distinction, presented him with many of the rarities of his country, furnished him with horses for travelling, and also gave him an escort of thirty troopers throughout the whole extent of his dominions. Spallanzani passed by Hermanstadt in Transylvania, and arrived at Vienna the 7th of December, after having viewed the numerous mines of Transylvania, of Hungary, and of Germany, which lay in the neighbourhood of his route. Spallanzani remained five days in this capital of Austria; he had two very long audiences with the Emperor Joseph II.; was well received by the highest nobility in that metropolis, and visited by the men of letters. At length arrived at Pavia; the students came to meet him out of the gates of the city, and accompanied him home, manifesting their joy all the way by repeated shouts. Their great desire to hear him, drew him almost immediately to the auditory, where they forced him to ascend the chair from which he had been accustomed to deliver his lectures to them. Spallanzani, affected by this scene, testified with eloquence his gratitude and [illegible] cries of joy, clapping of [illegible] force, and he was obliged [illegible] allow him to take in [illegible] more necessary than [illegible] year above 500 students.

Spallanzani had acquired glory enough to merit the attacks of envy; but his discoveries were too new, too original, too solid to be disputed; envy itself was therefore forced to admire him; but that unworthy passion, being [illegible] by the increasing reputation of that great man, watched the moment to prove that it had not forgotten him. Envy and malignity then called in question his uprightness in the administration of the cabinet of Pavia; the whole of which was the fruit of his own labours; but the blow aimed at —— only made it shine with new lustre. The integrity of Spallanzani appeared even more pure after the juridical examination of the tribunals. But let us stop here; Spallanzani had the fortitude to forget this event which had torn his heart to pieces; the greater part of his enemies acknowledged their mistake, abjured their hatred, and did not despair of regaining his friendship.

The cabinet of Pavia was always the object of Spallanzani's thoughts; amidst the numerous rarities which he had placed there, he only saw those that were wanting. Struck with its deficiency in volcanic matters, which had neither series nor order, and consequently excited little interest, being a mute article with respect to instruction (although Italy was the theatre where the fires of volcanoes had for so many ages exercised their desolating powers), he took the resolution, with which his talents, his courage, and his zeal, inspired

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him. He was desirous to instruct his pupils, his nation, himself, concerning the phenomena so striking, and yet so little known, and to collect the documents of their history in the places where they have always been the terror of those who surrounded them, and where they have been uselessly the subject of the observations of the philosopher. He therefore prepared himself for this great enterprise by deep studies. He set out for Naples, in the summer of 1788, and ascended mount Vesuvius; he looked attentively into its crater, examined and made notes in his books, and embarked for the Lipari islands. He dissected, as it were, the uninhabited volcanoes, with the exactness of a naturalist anatomising a butterfly, and the intrepidity of a warrior defying the most imminent dangers. It was then that he had the boldness to walk over that sulphurous crust, cleft with chinks, trembling, smoking, burning, and sometimes treacherously covering the hearth of the volcano. He passed into Sicily, where he climbed up to Etna, and coasted its immense crater. His curiosity not being exhausted, he would collect around him, and have in his mind, all the singular phenomena that Sicily contained; he examined the stones and the mountains, and discovered many new marine animals; he approached Scylla and Charybdis, and in a boat crossed the frothy billows of those deadly rocks, celebrated for so many shipwrecks, and so often sung by the poets; but in the very midst of their frightful waves, he discovered the cause of their fury (See SCYLLA, *Suppl.*) It was thus that, at the age of 60, he picked up those numberless anecdotes which fill his voyages in the two Sicilies; and that he compared the description which Homer, Pindar, Virgil, Diodorus Siculus, and Strabo, have given of these ever famous places, with that which he made himself. In this manner he showed the connection of ancient literature with natural history.

We find in the voyages of Spallanzani a new volcanology. He therein teaches the way to measure the intensity of the fire of volcanoes, to [illegible] at the causes, to touch almost, in the analysis which he makes of the lava, that particular gas which, resembling a powerful lever, [illegible] from the bowels of the earth and raises up to the top of Etna, those torrents of stone in fusion which it disgorges; to foresee the nature of those pumice stones, which he has since explained in his artificial pumice-stones. He concludes this charming work with some interesting inquiries into the nature of swallows, their mild dispositions, rapid flight; suggesting that an advantage might be drawn from them in the way of aerial post; their migrations determined by the temperature of the air, and the birth of insects it occasions; in short, he discusses the famous problem of their remaining benumbed during winter; and proves, that artificial cold, much greater than that ever naturally felt in our climates, does not render these birds lethargic. He next speaks of a species of owl, hitherto very ill described; and, lastly, of eels and their generation, which is a problem still in some measure to be solved; but he carries it on by his inquiries to that step which alone remains to be made for obtaining a complete solution; or to get over it easily by a small number of observations in those times and places pointed out, but which the academical occupations of Spallanzani forced him to give up to others.

Spallanzani followed the progress of the French chemistry with much satisfaction, nor was he long before he adopted it; it was calculated for a just conception like his, delighting to give an account of every phenomenon he observed. The solidity of principles in this new doctrine, the precision in its way of proceeding, the elegance of its interpretation, the generality of its consequences, presently replaced in his mind the hesitations and the obscurities of the ancient chemistry; and his heart anticipated with pleasure the triumphs that it was about to obtain.

In 1791, Spallanzani published a letter addressed to Professor Fortis, upon the Pennet Hydroscope. He there relates the experiments which he had directed to be made for ascertaining the degree of confidence which might be allowed to the singular talents of this man; but he ingenuously confesses, that he is not decided upon the reality of the phenomenon.

Spallanzani has often discovered that which mi[illegible] have been deemed impossible. In 1795 he made [illegible] covery of this nature, which he published in hi[illegible] *sopra il sospetto d'un nuovo senso nei Pipistrelli.* W[illegible] in learn that the bats, if blinded, act in every [illegible] with the same precision as those which have th[illegible], that they in the same manner avoid the most t[illegible] stacles, and that they know where to fix thems[illegible] ceasing their flight. These extraordinary experim[illegible] were confirmed by several natural philosophers, an[illegible] gave occasion to suspect a new sense in these birds, because Spallanzani thought he had evinced by the way of exclusion, that the other senses could not supply the deficiency of that sight which he had deprived them of; but the anatomical details of Professor Jurine, upon the organ of hearing in this singular bird, made him incline afterwards towards the idea, that the sense of hearing might in this case supply that of sight, as in all those where the bats are in the dark.

Spallanzani concluded his literary carreer for the public, by a letter addressed to the celebrated Giobert; *Sopra la piante chiuse ne' vasi dentro l'aqua e l'aria, esposte a l' immediata lume solare e a l'ombra.* It is a misfortune for this part of the science, that his death has deprived us of the discoveries he was about to make in it.

These numerous works, printed and applauded, did not however contain all the series of Spallanzani's labours. He had been occupied a considerable time upon the phenomena of respiration; their resemblances and differences in a great number of species of animals; and he was busily employed in reducing to order his researches upon this subject, which will astonish by the multitude of unforeseen and unexpected facts. He has left a precious collection of experiments and new observations upon animal reproductions, upon sponges, the nature of which he determines, and upon a thousand interesting phenomena which he knew how to draw out of obscurity. He had almost finished his voyage to Constantinople, and had amassed considerable materials for a History of the Sea, when an end was put to his life and his labours.

On the 4th of February 1799, he was seized with a retention of urine, the same night was unquiet, and in the morning he lost all powers of reason, which he never recovered but during very short intervals. His intimate friends, Tourdes, a French physician, and the celebrated Professor Scarpa, did every thing which could

could be expected from genius, experience, and friendship, to save him; but he died the 17th, after having edified those around him by his piety. This lamentable event overwhelmed all his family in sorrow, occasioned the tears to flow from all his friends, filled his disciples with a deep affliction, and excited the regret of a nation proud of having given him birth.

The reader cannot but have perceived in this sketch the strain of panegyric, rather than the calm narrative of impartial biography. It is, in fact, an abridged translation of an *eloge* by a *citizen* philosopher of Geneva, who has adopted the calendar, and probably the principles of republican France. Some abatement therefore will naturally be made by every Briton of the praises bestowed upon the piety of Spallanzani; but after proper allowance of this kind, truth will proclaim him a very great man. Accordingly, France, Germany, England, all were eager to avail themselves of his works by means of translations. He was admitted into the academies and learned societies of London, Stockholm, Gottingen, Holland, Lyons, Bologna, Turin, Padua, Mantua, and Geneva. He was a correspondent of the academy of sciences of Paris and of Montpelier: and received from the great Frederic himself the diploma of member of the academy of Berlin.

SPECIES, in algebra, are the letters, symbols, marks, or characters, which represent the quantities in any operation or equation.

SPECIES, in optics, the image painted on the retina by the rays of light reflected from the several points of the surface of an object, received in by the pupil, and collected in their passage through the crystalline, &c.

SPECTACLES (See *Encycl.*) are certainly the most valuable of all optical instruments, though there is not the same science and mechanical ingenuity displayed in the making of them as in the contruction of microscopes and telescopes. A man, especially if accustomed to spend his time among books, would be much to be pitied, when his sight begins to fail, could he not, in a great measure, restore it by the aid of spectacles; but there are some men whose sight cannot be aided by the use either of convex or concave glasses. The following method adopted by one of those to aid his sight is certainly worthy of notice:

When about sixty years of age, this man had almost entirely lost his sight, seeing nothing but a kind of thick mist, with little black specks which appeared to float in the air. He knew not any of his friends, he could not even distinguish a man from a woman, nor could he walk in the streets without being led. Glasses were of no use to him; the best print, seen through the best spectacles, seemed to him like a daubed paper. Wearied with this melancholy state, he thought of the following expedient.

He procured some spectacles with very large rings; and, taking out the glasses, substituted in each circle a conic tube of black Spanish copper. Looking through the large end of the cone he could read the smallest print placed at its other extremity. These tubes were of different lengths, and the openings at the end were also of different sizes; the smaller the aperture the better could he distinguish the smallest letters; the larger the aperture the more words or lines it commanded; and consequently the less occasion was there for moving the head and the hand in reading. Sometimes he used one eye, sometimes the other, alternately relieving each, for the rays of the two eyes could not unite upon the same object when thus separated by two opaque tubes. The thinner these tubes, the less troublesome are they. They must be totally blackened within so as to prevent all shining, and they should be made to lengthen or contract, and enlarge or reduce the aperture at pleasure.

When he placed convex glasses in these tubes, the letters indeed appeared larger, but not so clear and distinct as through the empty tube: he also found the tubes more convenient when not fixed in the spectacle rings; for when they hung loosely they could be raised or lowered with the hand, and one or both might be used as occasion required. It is almost needless to add, that the material of the tubes is of no importance, and that they may be made of iron or tin as well as of copper, provided the insides of them be sufficiently blackened. See *La Nouvelle Bigarure* for February 1754, or *Monthly Magazine* for April 1799.

SPECTRE OF THE BROKEN, a curious phenomenon observed on the summit of the *Broken*, one of the Harz mountains in Hanover. We have the following account of it by M. Haue. "After having been here (says he) for the thirtieth time, and having procured information respecting the abovementioned atmospheric phenomenon, I was at length, on the 23d of May 1797, so fortunate as to have the pleasure of seeing it; and perhaps my description may afford satisfaction to others who visit the Broken through curiosity. The sun rose about four o'clock, and, the atmosphere being quite serene towards the east, his rays could pass without any obstruction over the Heinrichshöhe. In the south-west, however, towards Achtermannshöhe, a brisk west wind carried before it thin transparent vapours, which were not yet condensed into thick heavy clouds.

"About a quarter past four I went towards the inn, and looked round to see whether the atmosphere would permit me to have a free prospect to the south-west; when I observed, at a very great distance towards Achtermannshöhe, a human figure of a monstrous size. A violent gust of wind having almost carried away my hat, I clapped my hand to it by moving my arm towards my head, and the colossal figure did the same.

"The pleasure which I felt on this discovery can hardly be described; for I had already walked many a weary step in the hopes of seeing this shadowy image, without being able to gratify my curiosity. I immediately made another movement by bending my body, and the colossal figure before me repeated it. I was desirous of doing the same thing once more—but my colossus had vanished. I remained in the same position, waiting to see whether it would return; and in a few minutes it again made its appearance on the Achtermannshöhe. I paid my respects to it a second time, and it did the same to me. I then called the landlord of the Broken; and having both taken the same position which I had taken alone, we looked towards the Achtermannshöhe, but saw nothing. We had not, however, stood long, when two such colossal figures were formed over the above eminence, which repeated our compliments by bending their bodies as we did; after which they vanished. We retained our position; kept our eyes fixed on the same spot, and in a little the two figures again stood before us, and were joined by a third. Every movement that we made by bending our bodies

bodies these figures imitated—but with this difference, that the phenomenon was sometimes weak and faint, sometimes strong and well defined. Having thus had an opportunity of discovering the whole secret of this phenomenon, I can give the following information to such of my readers as may be desirous of seeing it themselves. When the rising sun, and according to analogy the case will be the same at the setting sun, throws his rays over the Broken upon the body of a man standing opposite to fine light clouds floating around or hovering past him, he needs only fix his eyes stedfastly upon them, and, in all probability, he will see the singular spectacle of his own shadow extending to the length of five or six hundred feet, at the distance of about two miles before him."

If our memory does not deceive us, there is in one of the volumes of the *Manchester Transactions* an account of a similar phenomenon observed by Dr Ferrier, on a hill somewhere in England.

SPECULUM for reflecting telescopes. Under this title (*Encycl.*) we have given the composition of the mixt metal of which it has been found by experience that the best speculums are made; we have likewise given, under the same title, some directions for casting speculums; but owing to a circumstance in which the public can take no interest, we neglected to give directions for grinding and polishing them, and omitted some other circumstances, which, though not so important as these, are certainly worthy of notice. These omissions it is the object of this article to supply.

When the metal is taken out of the flasks (See n° 3. of the article referred to), which it should be as soon as it has become solid, and while it is yet red-hot, care must be taken to keep the face downwards to prevent it from sinking. Holding it in that position by the git, force out the sand from the hole in the middle of the mirror with a piece of wood or iron, and place the speculum in an iron pot with a large quantity of hot ashes or small coals, so as to bury the speculum in them a sufficient depth. If the sand is not forced out of the hole in the manner above directed, the metal, by sinking as it cools, will embrace the sand in the middle of the speculum so tight, as to cause it to crack before it becomes entirely cold. And if the metal is not taken out of the sand, and put in a pot with hot ashes or coals to anneal, the moisture from the sand will always break the metal. Let the speculum remain in the ashes till the whole becomes quite cold. The git may be easily taken off by marking it round with a common fine half round file, and giving it then a gentle blow. The metal is then to be rough ground and figured.

It may be proper, however, before we proceed to describe that process, to give an account of another composition for the speculum of a reflecting telescope, which has been employed with great success by Rochon director of the marine observatory at Brest. Of this composition the principal ingredient is platinum; which, in grains, must be purified in a strong fire by means of nitre and the salt of glass, or that flux which in the English glass-houses is called by the workmen *sandifer*. To the platinum, when purified, add the eighth part of the metal employed in the composition of common specula; for tin without red copper would not produce a good effect. This mixture is then to be exposed to the most violent heat, which must be still excited by the oxygen gas that disengages itself from nitre when thrown into the fire. One melting would be insufficient: five or six are requisite to bring the mixture to perfection. It is necessary that the metal should be in a state of complete fusion at the moment when it is poured into the mould. By this process I have been enabled (says our author) to construct a telescope with platinum, which magnifies the diameters of objects five hundred times, with a degree of clearness and distinctness requisite for the nicest observations. The large speculum of platinum weighs fourteen pounds: it is eight inches in diameter, and its focus is six feet. Though the high price of platinum will, in all probability, for ever prevent it from coming into general use for the speculums of telescopes, we thought it proper to notice this discovery, and shall now proceed to the grinding of the speculum.

For the accomplishing of this object, a very complicated process is recommended in Smith's Optics, and one not much more simpler by Mr Mudge in the 67th volume of the *Philosophical Transactions*; but according to Mr Edwards, whose speculums are confessedly the best, neither of these is necessary. Besides a common grindstone, all the tools that he made use of are a rough grinder, which serves also as a polisher, and a bed of hones. When the speculum was cold, he ground its surface bright on a common grindstone, previously brought to the form of the gage; and then took it to the rough grinder.

This tool is composed of a mixture of lead and tin, or of pewter, and is made of an elliptical form, of such dimensions, that the shortest diameter of the ellipse is equal to the diameter of the mirror or speculum, and the longest diameter is to the shortest in the proportion of ten to nine. This rough grinder may be fixed upon a block of wood, in order to raise it higher from the bench; and as the metal is ground upon it with fine emery, Mr Mudge, with whom, in this particular, Mr Edwards agrees, directs a hole or pit to be made in the middle of it as a lodgement for the emery, and deep grooves to be cut out across its surface with a graver for the same purpose. By means of a handle, fixed on the back of the metal with soft cement, the speculum can be whirled round upon this grinder so rapidly, that a common labourer has been known to give a piece of metal, four inches in diameter, so good a face and figure as to fit it for the hones in the space of two hours. The emery, however fine, will break up the metal very much; but that is remedied by the subsequent processes of honing and polishing.

When the metal is brought to a true figure, it must be taken to a convex tool, formed of some stones from a place called Edgedon in Shropshire, situated between Ludlow and Bishop's Castle. The common blue hones, used by many opticians for this purpose, will scarcely touch the metal of Mr Edwards's speculums; but where they must be employed for want of the others, as little water should be used as possible when the metal is put upon them; because it is found by experience that they cut better when but barely wet, than when drenched with water. The stones, however, from Edgedon are greatly preferable; for they cut the metal more easily, and having a very fine grain, they bring it to a smooth face. These stones are directed by Mr Mudge to be cemented in small pieces upon a thick round piece of

 marble,

Speculum.

marble, or of metal made of tin and lead like the former compoſition, in ſuch a manner, that the lines between the ſtones may run ſtraight from one ſide to the other; ſo that placing the teeth of a very fine ſaw in each of theſe diviſions, they may be cleared from one end to the other of the cement which riſes between the ſtones. As ſoon as the hones are cemented down, this tool muſt be fixed in the lathe, and turned as exactly true to the gage as poſſible. It ſhould be of a circular figure, and but very little larger than the metal intended to be figured upon it. If it be made conſiderably larger, it will grind the metal into a larger ſphere and a bad figure; and if it be made exactly of the ſame ſize, it will work the metal indeed into a figure truly ſpherical, but will be apt to ſhorten its focus, unleſs the metal and tool be worked alternately upwards. On theſe accounts, Mr Edwards recommends it to be made about one twentieth part longer in diameter than the ſpeculum, becauſe he has found that it does not then alter its focus; and he earneſtly diſſuades the uſe of much water on the hone pavement at the time of uſing it, otherwiſe, he ſays, that the metal in different parts of it will be of different degrees of brightneſs.

When the metal is brought to a very fine face and figure by the bed of ſtones, it is ready to receive a poliſh, which is given to it by the elliptical rough grinder covered with pitch. With reſpect to the conſiſtency of this pitch, Mr Mudge and Mr Edwards give very different directions. Whilſt the former ſays that it ſhould be neither too hard nor too ſoft, the latter affirms that the harder the pitch is, the better figure it will give to the metal. Pitch may be eaſily made of a ſufficient hardneſs by adding a proper quantity of roſin; and when it is hardened in this way, it is not ſo brittle as pitch alone, which is hardened by boiling. Mr Edwards adviſes to make the mixture juſt ſo hard as to receive, when cold, an impreſſion from a moderate preſſure of the nail of one's finger. When the elliptical tool is to be covered with this mixture, it muſt be made pretty warm, and in that ſtate have the mixture poured upon it when beginning to cool in the crucible. Our author recommends this coating to be made everywhere of about the thickneſs of half-a-crown; and to give it the proper form, it muſt, when ſomewhat cool, be preſſed upon the face of the mirror, which has firſt been dipped in cold water, or covered over with very fine writing paper. If it be not found to have taken the exact figure from the firſt preſſure, the ſurface of the pitch muſt be gently warmed, and the operation repeated as before. All the ſuperfluous pitch is now to be taken away from the edge of the poliſher with a penknife, and a hole to be made in the middle, accurately round, with a conical piece of wood. This hole ſhould go quite through the tool, and ſhould be made of the ſame ſize, or ſomewhat leſs than the hole in the middle of the ſpeculum. Mr Edwards ſays, that he has always found that ſmall mirrors, though without any hole in the middle, poliſh much better, and take a more correct figure, for the poliſher's having a hole in the middle of it.

The poliſher being thus formed, it muſt be very gently warmed at the fire, and divided into ſeveral ſquares by the edge of a knife. Theſe, by receiving the ſmall portion of metal that works off in poliſhing, will cauſe the figure of the ſpeculum to be more correct than if no ſuch ſquares had been made. Mr Mudge directs the poliſher to be ſtrewed over with very fine *putty*; but Mr Edwards prefers COLCOTHAR of vitriol. (See that article, *Encycl.*) Putty (ſays he) gives metals a white luſtre, or, as workmen call it, a ſilver hue; but good colcothar of vitriol will poliſh with a very fine and high black luſtre, ſo as to give the metal finiſhed with it the complection of poliſhed ſteel. To know if the colcothar of vitriol is good, put ſome of it into your mouth, and if you find it diſſolves away it is good; but if you find it hard, and crunch between your teeth, then it is bad, and not well burned. Good colcothar of vitriol is of a deep red, or of a deep purple colour, and is ſoft and oily when rubbed between the fingers; bad colcothar of vitriol is of a light red colour, and feels harſh and gritty. The colcothar of vitriol ſhould be levigated between two ſurfaces of poliſhed ſteel, and wrought with a little water; when it is worked dry, you may add a little more water, to carry it lower down to what degree you pleaſe. When the colcothar of vitriol has been wrought dry three or four times, it will acquire a black colour, and will be low enough, or ſufficiently fine, to give an exquiſite luſtre. This levigated colcothar of vitriol muſt be put into a ſmall phial, and kept with ſome water upon it. When it is to be uſed, every part of the pitch-poliſher muſt be firſt bruſhed over with a fine camel's hair bruſh, which has been dipped in pure water, and rubbed gently over a piece of dry clean ſoap. The waſhed colcothar of vitriol is then to be put upon the poliſher; and Mr Edwards directs a large quantity of it to be put on at once, ſo as to ſaturate the pitch, and form a fine coating. If a ſecond or third application of this powder be found neceſſary, it muſt be uſed very ſparingly, or the poliſh will be deſtroyed which has been already attained. When the metal is nearly poliſhed, there will always appear ſome black mud upon its ſurface, as well as upon the tool. Part of this muſt be wiped away with ſome very ſoft waſh leather; but if the whole of it be taken away, the poliſhing will not be ſo well completed.

With reſpect to the *parabolic figure* to be given to the mirror, Mr Edwards aſſures us, that a very little experience in theſe matters will enable any one to give it with certainty, by poliſhing the ſpeculum in the common manner, only with croſs ſtrokes in every direction, upon an elliptical tool of the proper dimenſions.

Speculum || Spinning-Machine.

SPINDLE, in geometry, a ſolid body generated by the revolution of ſome curve line about its baſe or double ordinate; in oppoſition to a conoid, which is generated by the rotation of the curve about its axis or abſciſs, perpendicular to its ordinate. The ſpindle is denominated circular, elliptic, hyperbolic, or parabolic, &c. according to the figure of its generating curve.

SPINDLE, in mechanics, ſometimes denotes the axis of a wheel, or roller, &c. and its ends are the pivots.

SPINNING MACHINE. The ancient Greeks were not, like the modern philoſophers, unwilling to acknowledge their obligations to Providence for all the comforts and enjoyments of life, nor felt pride in deriving every thing from their own talents. They were even diſpoſed to think that thoſe very talents were inſpired. Their firſt inſtructors, the poets, gave to Apollo the honour of that power of invention and imagination by which they inſtructed and charmed their admiring hearers. The propheteſs dictated her oracles, the

Spinning-Machine. the poet sung his enraptured strain only when inspired. The happy thought of twining a thread, and working it into a blanket, when viewed by that ingenious and acutely sensible people in all its importance, as the protector of the human race from the severity of the weather, seemed a present from heaven, as the inspiration of a divinity; and the distaff and the loom were Minerva's first title to a seat among the great gods on Olympus.

We are much inclined to be of the same opinion. When we observe, that in all the countries which have been discovered by the navigators of the three last centuries, the distaff and spindle, and the needle, have been found, we own ourselves much disposed to think that they are the results of instinct. Our instincts are not all simple and blind, like that which directs the new-born animal to the breast of its mother without knowing why. We have instincts of intellect as well as of appetite; and the logic of common conversation is an example of many such. We doubt not but that the noble-minded inhabitants of Pelew would have worshipped as a divinity an English maiden with her spinning wheel and fly. Surely he who should carry them this homely but ingenious machine, and a potter's wheel, would do them more service than if he taught them all the science of a Newton, with all the philosophy of the 18th century into the bargain. We do not know, except perhaps the steam engine, any mechanical invention that has made such amazing addition to the activity and industry and opulence of this highly favoured island, as the invention of Mr Arkwright for spinning by water, where dead matter is made to perform all the nicest finger can do when directed by the never-ceasing attention of the intelligent eye. Minerva has the undisputed honours of the distaff and spindle. We know not to what benefactor we owe the fly-wheel. Mr Arkwright has the honour of combining them both, and inspiring them with his own spirit; for we may truly say of the contrivance which pervades the wonderful machinery of a cotton mill,

Totosque infusa per artus
Mens agitat molem et magno se corpore miscet.

To give an intelligible and accurate description of a cotton mill would be abundant employment for a volume. Our limits admit of nothing like this; but as we are certain that many of our readers have viewed a cotton mill with wonder, but not with intelligence, nor with leisure to trace the steps by which the wool from the bag ultimately assumes the form of a very fine thread. Bewildered by such a complication of machinery, all in rapid motion, very few, we imagine, are able to recollect with distinctness and intelligence the essential part of the process by which the form of the cotton is so wonderfully changed. Such readers will not think a page or two misemployed, if they are thereby able to understand this particular, to which all the rest of the process is subservient.

We pass over the operation of carding, by which all the clots and inequalities of the cotton wool are removed, and the whole is reduced to an uniform thin fleece, about 20 inches broad. This is gradually detached from the finishing card, and, if allowed to hang down from it, would pile up on the floor as long as the mill continues to work; but it is guided off from the card, very tenderly, in a horizontal direction, by laying its detached end over a roller, which is slowly turned round by the machine. Another roller lies above the fleece, pressing it down by its weight. By this pressure, a gentle hold is taken of the fleece, and therefore the slow motion of the rollers draws it gently from the card at the same rate as it is disengaged by the comb; but between the card and the rollers a set of smooth pins are placed in two rows, leading from the card to the rollers, and gradually approaching each other as we approach the rollers. By these pins the broad fleece is hemmed in on both sides, and gradually contracted into a thick roll; and in this state passes between the rollers, and is compressed into a pretty firm flat riband, about two inches broad, which falls off from the rollers, and piles up in deep tinplate cans set below to receive it.

It is upon this stripe or riband of cotton wool that the operation of spinning begins. The general effect of the spinning process is to draw out this massive roll, and to twist it as it is drawn out. But this is not to be done by the fingers, pulling out as many cotton fibres at once as are necessary for composing a thread of the intended fineness, and continuing this manipulation regularly across the whole end of the riband, and thus, as it were, nibbling the whole of it away. The fingers must be directed, for this purpose, by an attentive eye. But in performing this by machinery, the whole riband must be drawn out together, and twisted as it is drawn. This requires great art, and very delicate management. It cannot be done at once; that is, the cotton roll cannot first be stretched or drawn out to the length that is ultimately produced from a tenth of an inch of the roll, and then be twisted. There is not cohesion enough for this purpose; we should only break off a bit of the roll, and could make no farther use of it. The fibres of cotton are very little implicated among each other in the roll, because the operation of carding has laid them almost parallel in the roll; and though compressed a little by its contraction from a fleece of 20 inches to a riband of only 2, and afterwards compressed between the discharging rollers of the carding machine, yet they cohere so slightly, that a few fibres may be drawn out without bringing many others along with them. For these reasons, the whole thickness and breadth of two or three inches of the riband is stretched to a very minute quantity, and then a very slight degree of twist is given it, viz. about three turns in the inch; so that it shall now compose an extremely soft and spungy cylinder, which cannot be called a thread or cord, because it has scarcely any firmness, and is merely rounder and much slenderer than before, being stretched to about thrice its former length. It is now called slab, or roove.

Although it be still extremely tender, and will not carry a weight of two ounces, it is much more cohesive than before, because the twist given to it makes all the longitudinal fibres bind each other together, and compress those which lie athwart; therefore it will require more force to pull a fibre from among the rest, but still not nearly enough to break it. In drawing out a single fibre, others are drawn out along with it; and if we take hold of the whole assemblage, in two places, about an inch or two inches asunder, we shall find that we may draw it to near twice its length without any

risk of its separating in any intermediate part, or becoming much smaller in one part than another. It seems to yield equably over all.

Such is the state of the slab or roove of the first formation. It is usually called the *preparation;* and the operation of spinning is considered as not yet begun. This preparation is the most tedious, and requires more attendance and hand labour than any subsequent part of the process. For the stripes or ribands from which it is made are so light and bulky, that a few yards only can be piled up in the cans set to receive them. A person must therefore attend each thread of slab, to join fresh stripes as they are expended. It is also the most important in the manufacture; for as every inch of the slab meets with precisely the same drawing and the same twisting in the subsequent parts of the process, therefore every inequality and fault in the slab (indeed in the fleece as it quits the finishing card) will continue through the whole manufacture. The spinning of cotton yarn now divides into two branches. The first, performed by what are called *jennies*, perfectly resembles the ancient spinning with the distaff and spindle; the other, called *spinning of twist*, is an imitation of the spinning with the fly-wheel. They differ in the same manner as the spinning with the old wool or cotton-wheel differs from the spinning with the flax-wheel. Mr Arkwright's chief invention, the substitution of machinery for the immediate work of the human finger, is seen only in the manufacture of twist. We shall therefore confine our attention to this.

The rest of the process is little more than a repetition of that gone through in making the first slab or roove. It is formed on bobins. These are set on the back part of the drawing frame; and the end of the slab is brought forwards toward the attending workman. As it comes forward, it is stretched or drawn to about $\frac{4}{5}$ of its former length, or lengthened $\frac{1}{4}$; and is then twisted about twice as much as before, and in this state wound up on another bobin. In some mills two rooves, after having been properly drawn, are brought together through one hole, and twisted into one; but we believe that, in the greater number of mills, this is deferred to the second drawing. It is only after the first drawing that the produce of the operation gets the name of *slab;* before this it is called *preparation*, or *roove*, or by some other name. The slab is still a very feeble, soft, and delicate yarn, and will not carry much more weight than it did before in the form of roove. The perfection of the ultimate thread or yarn depends on this extreme softness; for it is this only which makes it susceptible of an equable stretching; all the fibres yielding and separating alike.

The next operation is the *second drawing*, which no way differs from the first, except in the different proportions of the lengthening, and the proportion between the lengthening and the subsequent twist. On these points we cannot give any very distinct information. It is different in different mills, and with different species of cotton wool, as may be easily imagined. The immediate mechanism or manipulation must be skilfully accommodated to the nature of that friction which the fibres of cotton exert on each other, enabling one of them to pull others along with it. This is greatly aided by the contorted curled form of a cotton fibre, and a considerable degree of elasticity which it possesses. In this respect it greatly resembles woollen fibres, and differs exceedingly from those of flax: and it is for this reason that it is scarcely possible to spin flax in this way: its fibres become lank, and take any shape by the slightest compression, especially when damp in the slightest degree. But besides this, the surface of a cotton fibre has a harshness or roughness, which greatly augments their mutual friction. This is probably the reason why it is so unfit for tents and other dressings for wounds, and is refused by the surgeon even in the meanest hospitals. But this harshness and its elasticity, fit it admirably for the manufacture of yarn. Even the shortness of the fibre is favourable; and the manufacture would hardly be possible if the fibre were thrice as long as it generally is. If it be just so long that in the finished thread a fibre will rather break than come out from among the rest, it is plain that no additional length can make the yarn any stronger with the same degree of compression by twining. A longer fibre will indeed give the same firmness of adherence with a smaller compression. This would be an advantage in any other yarn; but in cotton yarn the compression is already as slight as can be allowed; were it less, it would become woolly and rough by the smallest usage, and is already too much disposed to teazle out. It can hardly be used as sewing thread. Now suppose the fibres much longer; some of them may chance to be stretched along the slab through their whole length. If the slab is pulled in opposite directions, by pinching it at each end of such [illegible] it will not stretch till this fibre be broken [illegible] while it is in its extended [illegible] fibres in a very unequable [illegible] positions, and [illegible] irregularly. [illegible] of flax by similar [illegible] vented (we [illegible]) the working up of any thing but the *shorts* or tow, [illegible] flax in the operation of heckling.

A third, and sometimes even a fourth, drawing is given to the slab formed on the bobins of this second operation. [illegible] still [illegible] of considerable extension, [illegible] smallest [illegible] In one of [illegible] scribed, [illegible] former drawings, [illegible] them. The practice [illegible] plain, that unless great care be taken to preserve the slab extremely soft and [illegible] during the whole process, the subsequent drawing becomes more precarious, and we run a risk of at last making a bad and loose thread instead of a uniform and simple yarn. Such a thread will have very little lateral connection, and will not bear much handling without separating into strands. The perfection of the yarn depends on having the last slab as free of all appearance of strands as possible.

The last operation is the spinning this slab. This hardly differs from the foregoing drawings in any thing but the twist that is given it after the last stretching in its length. This is much greater than any of the preceding, being intended to give the yarn hardness and firmness, so that it will now break rather than stretch any more.

The

The reader, moderately acquainted with mechanics, cannot but perceive that each of the operations now described, by which the roove is changed into the soft flab, and each of these into one slenderer and somewhat firmer, by alternately teazling out and twining the soft cord, is a substitute for a single pull of the finger and thumb of the spinster, which she accommodates precisely to the peculiar condition of the lock of wool which she touches at the moment. She can follow this thro' all its irregularities; and perhaps no two succeeding plucks are alike. But when we cannot give this momentary attention to every minute portion, we must be careful to introduce the roove in a state of perfect uniformity; and then every inch being treated in the same manner, the final result will be equable—the yarn will be uniform.

We are now to describe the mechanism by which all this is effected. But we do not mean to describe a cotton mill; we only mean to describe what comes into immediate contact with the thread; and in so doing, to confine ourselves to what is necessary for making the reader perceive its ability to perform the required task. We see many cases where individuals can apply this knowledge to useful purposes. More than this would, we think, be improper, in a national point of view.

Let ABC represent the section of a roller whose pivot D does not turn in a pivot hole, but in the bottom of a long narrow notch DE, cut in an iron standard: *abc* is the section of another iron roller, whose pivot *d* is in the same notches at each end, while the roller itself lies or rests on the roller ABC below. The surfaces of these rollers are fluted lengthwise [illegible] only the flutings are very small, and [illegible] close together. [illegible] ABC be made to [illegible] in the direction [illegible] the roughness of [illegible] of the upper roller *abc* [illegible] the [illegible] DE [illegible]. If there[illegible] band [illegible] will be pulled in by this [illegible] side at H, [illegible] by the weight of the upper roller, [illegible] down by a lever [illegible] proper places, and is loaded [illegible]. There is nothing to hinder this motion of the riband thus compressed between the rollers; and it will therefore be drawn thro' from the cans. The compressed part at H would hang down, and be piled up on the floor as it is drawn thro'; but it is not permitted to hang down in this manner, but is brought to another pair of sharp fluted iron rollers K and L. Supposing this pair of rollers to be of the same diameter, and to turn round in the same time, and in the same direction with the rollers ABC, *abc*; it is plain that K and L drag in the compressed riband at I, and would deliver it on the other side at M, still more compressed. But the roller K is made (by the wheelwork) to turn round more swiftly than ABC. The difference of velocity at the surface of the rollers is, however, very small, seldom exceeding one part in 12 or 15. But the consequence of this difference is, that the skein of cotton HI will be lengthened in the same proportion; for the upper rollers pressing on the under ones with a considerable force, their sharp flutings take good hold of the cotton between them; and since K and L take up the cotton faster than ABC, and *abc* deliver it out, it must either be forcibly pulled through between the first rollers, or it must be stretched a little by the fibres slipping among each other, or it must break. When the extension is so very moderate as we have just now said, the only effect of it is merely to begin to draw the fibres (which at present are lying in every possible direction) into a more favourable position for the subsequent extensions.

Spinning-Machine.

The fibres being thus drawn together into a more favourable position, the cotton is introduced between a third pair of rollers O, P, constructed in the same way, but so moved by the wheelwork that the surface of O moves nearly or fully twice as fast as the surface of K. The roller P being also well loaded, they take a firm hold of the cotton, and the part between K and O is nearly or fully doubled in its length, and now requires a little twining to make it roundish, and to consolidate it a little.

It is therefore led sloping downwards into a hole or eye in the upper pivot of the first fly, called a *jack*. This turns round an upright axis or spindle; the lower end of which has a pulley on it to give it motion by means of a band or belt, which passes round a drum that is turned by the machinery. This jack is of a very ingenious and complicated construction. It is a substitute for the fly of the common spinning wheel. If made precisely in the form of that fly, the thread, being so very bulky and spongy, and unable to bear close packing on the bobin, would swag out by the whirling of the fly, and would never coil up. The bobin therefore is made to lie horizontally; and this occasions the complication, by the difficulty of giving it a motion round a horizontal axis, in order to coil up the twisted roove. Mr Arkwright has accomplished this in a very ingenious manner; the essential circumstances of which we shall here briefly describe. A is a roller of hard wood, having its surface cut into sharp flutes longitudinally. On the axis, which projects through the side of the general frame, there is a pulley B, connected by a band with another pulley Q, turning with the horizontal axis QR. This axis is made to turn by a contrivance which is different in every different cotton mill. The simplest of all is to place above the pulley C (which is turned by the great band of the machinery, and thus gives motion to the jack), a thin circular disc D, loose upon the axis, so as to turn round on it without obstruction. If this disc exceed the pulley in breadth about [illegible]th of an inch, the broad belt which turns the pulley will also turn it; but as its diameter is greater than that of the pulley, it will turn somewhat slower, and will therefore have a relative motion with respect to the axis QR. This can be employed, in order to give that axis a very slow motion, such as one turn of it for 20 or 30 of the jack. This we leave to the ingenuity of the reader. The bobin B, on which the roove is to be coiled up, lies on this roller, its pivots passing through upright slits in the sides of the general frame. It lies on A, and is moved round by it, in the same manner as the uppermost of a pair of drawing rollers lies on the under one, and receives motion from it. It is evident that the fluted surface of A, by turning, slowly

ſlowly round, and carrying the weight of the bobin, compreſſes a little the cotton that is between them; and its flutings, being ſharp, take a ſlight hold of it, and cauſe it to turn round alſo, and thus coil up the roove, pulling it in through the hole E in the upper pivot (which reſembles the fore pivot or eye of a ſpinning wheel fly) in ſo gentle a manner as to yield whenever the motion of the bobin is too great for the ſpeed with which the cotton ſkein is diſcharged by the rollers O and P.—*N. B.* The axis QR below, alſo gives motion to a guide within the jack, which leads the roove gradually from one end of the bobin to the other, and back again, ſo as to coil it with regularity till the bobin is full. The whole of this internal mechaniſm of the jack is commonly ſhut up in a tin cylinder. This is particularly neceſſary when the whirling motion muſt be rapid, as in the ſecond and third drawings. If open, the jacks would meet with much reſiſtance from the air, which would load the mill with a great deal of uſeleſs work.

The reader is deſired now to return to the beginning of the proceſs, and to conſider it attentively in its different ſtages. We apprehend that the deſcription is ſufficiently perſpicuous to make him perceive the efficacy of the mechaniſm to execute all that is wanted, and prepare a ſlab that is uniform, ſoft, and ſtill very extenſible; in ſhort, fit for undergoing the laſt treatment, by which it is made a fine and firm yarn.

As this part of the proceſs differs from each of the former, merely by the degree of twiſt that is given to the yarn, and as this is given by means of a fly, not materially different from that of the ſpinning wheel for flax, we do not think it at all neceſſary to ſay any thing more about it.

The intelligent reader is ſurely ſenſible that the yarn produced in this way muſt be exceedingly uniform. The uniformity really produced even exceeds all expectation; for even although there be ſome ſmall inequalities in the carded fleece, yet if theſe are not matted clots, which the card could not equaliſe, and only conſiſt of a little more thickneſs of cotton in ſome places than in others, when ſuch a piece of the ſtripe comes to the firſt roller, it will be rather more ſtretched by the ſecond, and again by the bobin, after the firſt very ſlight twining. That this may be done with greater certainty, the weights of the firſt rooving rollers are made very ſmall, ſo that the middle part of the ſkein can be drawn through, while the outer parts remain faſt held.

We are informed that a pound of the fineſt Bourbon cotton has been ſpun into a yarn extending a few yards beyond 119 miles!

Elater SPRING, in phyſics, denotes a natural faculty, or endeavour, of certain bodies to return to their firſt ſtate, after having been violently put out of the ſame by compreſſing, or bending them, or the like. This faculty is uſually called by philoſophers *elaſtic force*, or *elaſticity*.

T. SQUARE, or *Tee Square*, an inſtrument uſed in drawing, ſo called from its reſemblance to the capital letter T.

STAPELIA, a genus of plants belonging to the claſs pentandria, in the Linnæan arrangement, and to the order digynia. The generic characters are the following: The *calyx* is monophyllous, quinquefid, acute, ſmall, and permanent. The *corolla* is monopetalous, flat, large, and divided, deeper than the middle, into five parts, with broad, flat, pointed *laciniæ*. The *nectarium* is ſmall, ſtar-ſhaped, flat, quinquefid, with linear *laciniæ*; and embracing with its ragged points the ſeed-forming parts. Another ſmall ſtar, which is alſo flat and quinquefid, covers the ſeminiferous parts with its entire acute *laciniæ*. The *ſtamina* are five in number; the *filaments* are erect, flat, and broad; and the *antheræ* are linear, on each ſide united to the ſide of the filament. The *piſtillum* has two *germina*, which are oval and flat on the inſide. There are no *ſtyles*; and the *ſtigmata* are obſolete. The *ſeed-veſſel* conſiſts of two oblong, awl-ſhaped, unilocular and univalved follicles. The *ſeeds* are numerous, imbricated, compreſſed, and crowned with a *pappus* or down.

This ſingular tribe of plants is peculiar to the ſandy deſerts of Africa and Arabia. They are extremely ſucculent. From this peculiarity of ſtructure, the power of retaining water to ſupport and nouriſh them, they are enabled to live during the prevalent droughts of thoſe arid regions. On this account the ſtapelia has been compared to the camel; and we are told that, by a very apt ſimilitude, it has been denominated "the *camel* of the vegetable kingdom." We muſt confeſs ourſelves quite at a loſs to ſee the propriety or aptitude of this compariſon. In many parts of the animal and vegetable economy there is doubtleſs a very obvious and ſtriking analogy; but this analogy has been often carried too far; much farther than fair experiment and accurate obſervation will in any degree ſupport. It is perhaps owing to this inaccuracy in obſerving the peculiarity of ſtructure and diverſity of functions, that a reſemblance is ſuppoſed to exiſt, as in the inſtance before us, where in reality there is none. The camel is furniſhed with a bag or fifth ſtomach, [illegible] with which ruminant animals are provided. This fifth ſtomach is deſtined as a reſervoir to contain water; and it is ſufficiently capacious to receive a quantity of that neceſſary fluid, equal to the wants of the animal for many days; and this water, as long as it remains in the fifth ſtomach, is ſaid to be perfectly pure and unchanged. The ſtapelia, and other ſucculent plants, have no ſuch reſervoir. The water is equally, or nearly ſo, diffuſed through the whole plant. Every veſſel and every cell is fully diſtended. But beſides, this water, whether it be received by the roots, or abſorbed from the atmoſphere, has probably undergone a complete change, and become, after it has been a ſhort time within the plant, a fluid poſſeſſed of very different qualities.

The peculiar economy in the ſtapelia, and other ſucculent plants, ſeems to exiſt in the abſorbent and exhalant ſyſtems. The power of abſorption is as much increaſed as the power of the exhalant or perſpiratory veſſels is diminiſhed. In theſe plants, a ſmall quantity of nouriſhment is required. There is no ſolid part to be formed, no large fruit to be produced. They generally have very ſmall leaves, often are entirely naked; ſo that taking the whole plant, a ſmall ſurface only is expoſed to the action of light and heat, and conſequently a much ſmaller proportion of water is decompoſed than in plants which are much branched and furniſhed with leaves.

Two ſpecies of ſtapelia only were known at the beginning of the century. The unfortunate Forſkål, the companion

companion of Niebhur, who was sent out by the king of Denmark to explore the interior of Arabia, and who fell a sacrifice to the pestilential diseases of those inhospitable regions, discovered two new species. Thunberg, in his *Prodromus*, has mentioned five more. Forty new species have been discovered by Mr Masson of Kew Gardens, who was sent out by his present Majesty for the purpose of collecting plants round the Cape of Good Hope. Descriptions of these, with elegant and highly finished coloured engravings, have lately been published. They are chiefly natives of the extensive deserts called *Karro*, on the western side of the Cape.

STAR, in fortification, denotes a small fort, having five or more points, or saliant and re-entering angles, flanking one another, and their faces 90 or 100 feet long.

STARCH (see *Encycl.*) is commonly made of wheat, and the very best starch can perhaps be made of nothing else. Wheat, however, is too valuable an article of food to be employed as the material of starch, when any thing else will answer the purpose; and it has long been known that an inferior kind of starch may be made of potatoes. Potatoes, however, are themselves a valuable article of food; and it is therefore an object of importance to try if starch may not be made of something still less useful.

On the 8th of March 1796, a patent was granted to Lord William Murray for his discovery of a method by which starch may be extracted from horse-chesnuts. That method is as follows:

Take the horse-chesnuts out of the outward green prickly husks; and then either by hand, with a knife or other tool, or with a mill adapted for that purpose, carefully pare off all the brown rind, being particularly careful not to leave the smallest speck, and to entirely eradicate the sprout or growth. Next take the nuts, and rasp, grate, or grind them fine into water, either by hand, or by a mill adapted for that purpose. Wash the pulp, which is thereby formed in this water, as clean as possible, through a coarse horse-hair sieve; then again wash through a finer sieve, and then again through a still finer, constantly adding clean water to prevent any starch from adhering to the pulp. The last process is, to put it with a large quantity of water (about four gallons to a pound of starch) through a fine gauze, muslin, or lawn, so as entirely to clear it of all bran or other impurities. As soon as it settles, pour off the water; then mix it up with clean water, repeating this operation till it no longer imparts any green, yellow, or other colour to the water. Then drain it off till nearly dry, and set it to bake, either in the usual mode of baking starch, or else spread out before a brisk fire; being very attentive to stir it frequently to prevent its horning, that is to say, turning to a paste or jelly, which, on being dried, turns hard like horn. The whole process should be conducted as quickly as possible.

Mention is here made of a mill which may be employed to grind the horse-chesnuts; but none is described as proper for that purpose. Perhaps the following mill, which was invented by M. Baumé for grinding potatoes, with a view to extract starch from them, may answer for grinding horse chesnuts.

He had a grater made of plate iron, in a cylindrical form (fig. 1.) about seven inches in diameter, and about eight inches high: the burs made by stamping the holes are on the inside. This grater is supported upon three feet AAA, made of flat iron bars, seven feet high, strongly rivetted to the grater; the bottom of each foot is bent horizontally, and has a hole in it which receives a screw, as at A, fig. 4. A little below the upper end of the three feet is fixed a cross piece B (fig. 1. and 4.), divided into three branches, and rivetted to the feet. This cross piece not only serves to keep the feet at a proper distance from each other, and to prevent their bending; but the centre of it having a hole cut in it, serves to support an axis or spindle of iron, to be presently described.

The upper end of this cylindrical grater has a diverging border of iron C (fig. 1. 4. and 7.), about ten inches in diameter at the top, and five inches in height.

Within this cylindrical grater is placed a second grater (fig. 2. and 3.), in the form of a cone, the point of which is cut off. The latter is made of thick plate iron, and the burs of the holes are on the outside: it is fixed, with the broad end at the bottom, as in fig. 4. At the upper end of the cone is rivetted a small triangle, or cross piece of iron, consisting of three branches D (fig. 2.), in the middle of which is made a square hole, to receive an axis or spindle; to give more resistance to this part of the cone, it is strengthened by means of a cap of iron E, which is fixed to the grater by means of rivets, and has also a square hole made in it, to let the axis pass through.

Fig. 3. represents the same cone seen in front; the base F has also a cross piece of three branches, rivetted to a hoop of iron, which is fixed to the inner surface of the cone; the centre of this cross piece has also a square hole for the passage of the axis.

Fig. 5. is a spindle or axis itself; it is a square bar of iron about 16 inches long, and more than half an inch thick; round at the bottom, and also towards the top, where it fits into the cross piece I, fig. 7. and B, fig. 1. and 4.; in these pieces it turns round, and by them it is kept in its place. It must be square at its upper extremity, that it may have a handle, about nine inches long, fixed to it, by means of which the conical grater is turned round. At G, (fig. 5.), a small hole is made through the axis, to receive a pin H, by means of which the conical grater is kept [illegible] within the cylindrical one.

Fig. 6. is a bird's eye view, in [illegible] presented placed in an oval tub, li[illegible] is the fore-mentioned triangular iron cross, fixed with screws to the side of the tub; the centre of it has a round hole, for the axis of the mill to move in when it is used.

Fig. 7. represents the mill in the oval tub; it is placed at one end of it, that the other end may be left free for any operation to be performed in it which may be necessary. A part of the tub is cut off, that the inside of it, and the manner of fixing the mill, may be seen. That the bottom of the tub may not be worn by the screws which pass through the feet of the mill, a deal board, about an inch thick, and properly shaped, is placed under the mill.

When we wish to make use of this mill, it is to be fixed by the feet, in the manner already described; it is also fixed at the top, by means of the cross piece I, fig. 6. and 7. The tub is then to have water poured into

Starch.

into it as high as K, and the top of the mill is to be filled with potatoes, properly washed and cut; the handle L is to be turned round, and the potatoes, after being ground between the two graters, go out gradually at the lower part, being assisted by the motion produced in the water by the action of the mill.

It is not necessary, in the construction of such a mill, to be very particular with respect to its proportions; but, in order to make known those which experience has proved to be good ones, a scale is given with the figures, to which recourse may be had. With a mill of this size, 100 pounds of potatoes may be ground in the space of two hours.

We are persuaded that this mill will answer perfectly well for grinding horse-chesnuts; and we hope, that where they can be had they will be used in preference to potatoes. We shall, however, give M. Baumé's method of extracting starch from the ground potatoes, not only because it will be acceptable to those who have not horse-chesnuts, but also because those who have may, by following it, be able, perhaps, to make starch of them, without encroaching upon Lord William Murray's patent.

In order to prepare starch from potatoes, says M. Baumé, any quantity of these roots may be taken, and soaked in a tub of water for about an hour; they are afterwards to have their fibres and shoots taken off, and then to be rubbed with a pretty strong brush, that the earth, which is apt to lodge in the inequalities of their surface, may be entirely removed; as this is done, they are to be washed, and thrown into another tub full of clean water. When the quantity which we mean to make use of has been thus treated, those which are too large are to be cut into pieces about the size of eggs, and thrown into the mill; that being already fixed in the oval tub, with the proper quantity of water; the handle is then turned round, and as the potatoes are grated they pass out at the bottom of the mill. The pulp which collects about the mill must be taken off from time to time with a wooden spoon, and put aside in water.

When all the potatoes are ground, the whole of the pulp is to be collected in a tub, and mixed up with a great quantity of clean water. At the same time, another tub, very clean, is to be prepared, on the brim of which are to be placed two wooden rails, to support a hair sieve, which must not be too fine. The pulp and water are to be thrown into the sieve; the flour passes through with the water, and fresh quantities of water are successively to be poured on the remaining pulp, till the water runs through as clear as it is poured in. In this way we are to proceed till all the potatoes that were ground are used.

The pulp is commonly thrown away as useless; but it should be boiled in water, and used as food for animals; for it is very nourishing, and is about [illegible] of the whole quantity of potatoes used.

To return from this short digression. The liquor which has passed through the sieve is turbid, and of a brownish colour, on account of the extractive matter which is dissolved in it; it deposits, in the space of five or six hours, the flour which was suspended in it. When all the flour is settled to the bottom, the liquor is to be poured off and thrown away, being useless; a great quantity of very clean water is then to be poured upon the flour remaining at the bottom of the tub, which is to be stirred up in the water, that it may be washed, and the whole is to stand quiet till the day following. The flour will then be found to have settled at the bottom of the tub; the water is again to be poured off as useless, the flour washed in a fresh quantity of pure water, and the mixture passed through a silk sieve pretty fine, which will retain any small quantity of pulp which may have passed through the hair sieve. The whole must once more be suffered to stand quiet till the flour is entirely settled; if the water above it is perfectly clear and colourless, the flour has been sufficiently washed; but if the water has any sensible appearance either of colour or of taste, the flour must be again washed, as it is absolutely necessary that none of the extractive matter be suffered to remain.

When the flour is sufficiently washed, it may be taken out of the tub with a wooden spoon; it is to be placed upon wicker frames covered with paper, and dried, properly defended from dust. When it is thoroughly dry, it is to be passed through a silk sieve, that if any clotted lumps should have been formed they may be divided. It is to be kept in glass vessels stopped with paper only. See *Vegetable Substances*, Suppl.

N. B. Almost all the flour of potatoes that is to be bought contains a small quantity of sand, which is perceived between the teeth; it is owing to the potatoes not having been properly washed; for the sand which lodges in the knobs and wrinkles of these roots, is not always easy to get out.

Starch ‖ Steam.

STARLINGS, or STERLINGS, [illegible] to the strong pieces of timber [illegible] the bed of the river to [illegible] of which were laid the [illegible] the bases of the stone piers [illegible] London bridge. In general [illegible] placed on the outside of the [illegible] of bridges, to break the force of [illegible] protect the stone work from injury by [illegible]. They are otherwise called JETTEES, which [illegible]; and their place is often supplied by large stones thrown at random round the piers of bridges, as may be seen at Stirling bridge when the river is low, and as was done by Mr Smeaton's direction round the piers of the centre arch of London bridge, when it was thought in danger of being undermined by the current. See SMEATON, *Encycl.*

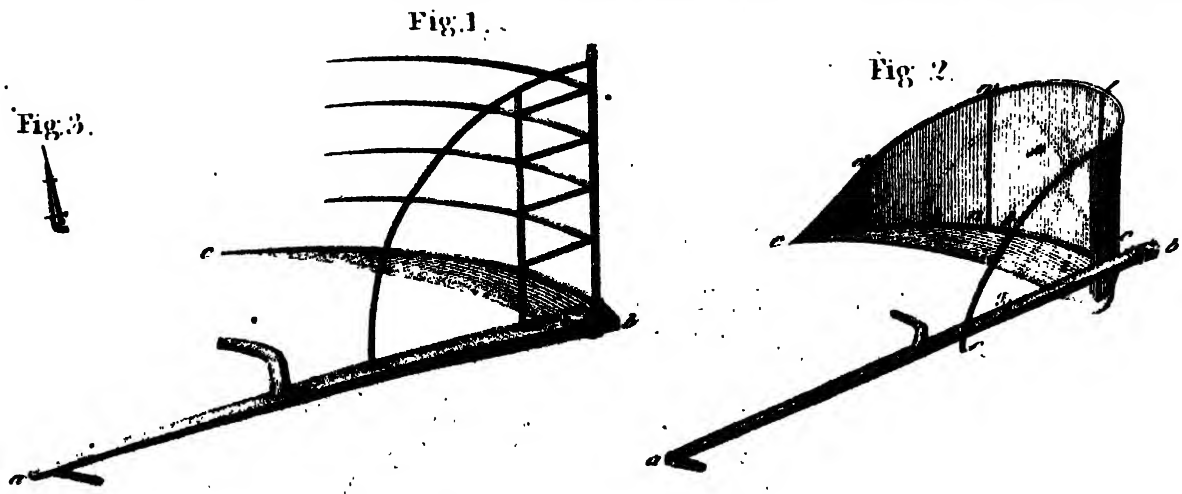
STATIONARY, in astronomy, the state of a planet when, to an observer on the earth, it appears for some time to stand still, or remain immoveable in the same place in the heavens. For as the planets, to such an observer, have sometimes a progressive motion, and sometimes a retrograde one, there must be some point between the two where they must appear stationary.

STEAM, STEAM-ENGINE. The few following corrections of these articles in the *Encycl.* were communicated by the author.

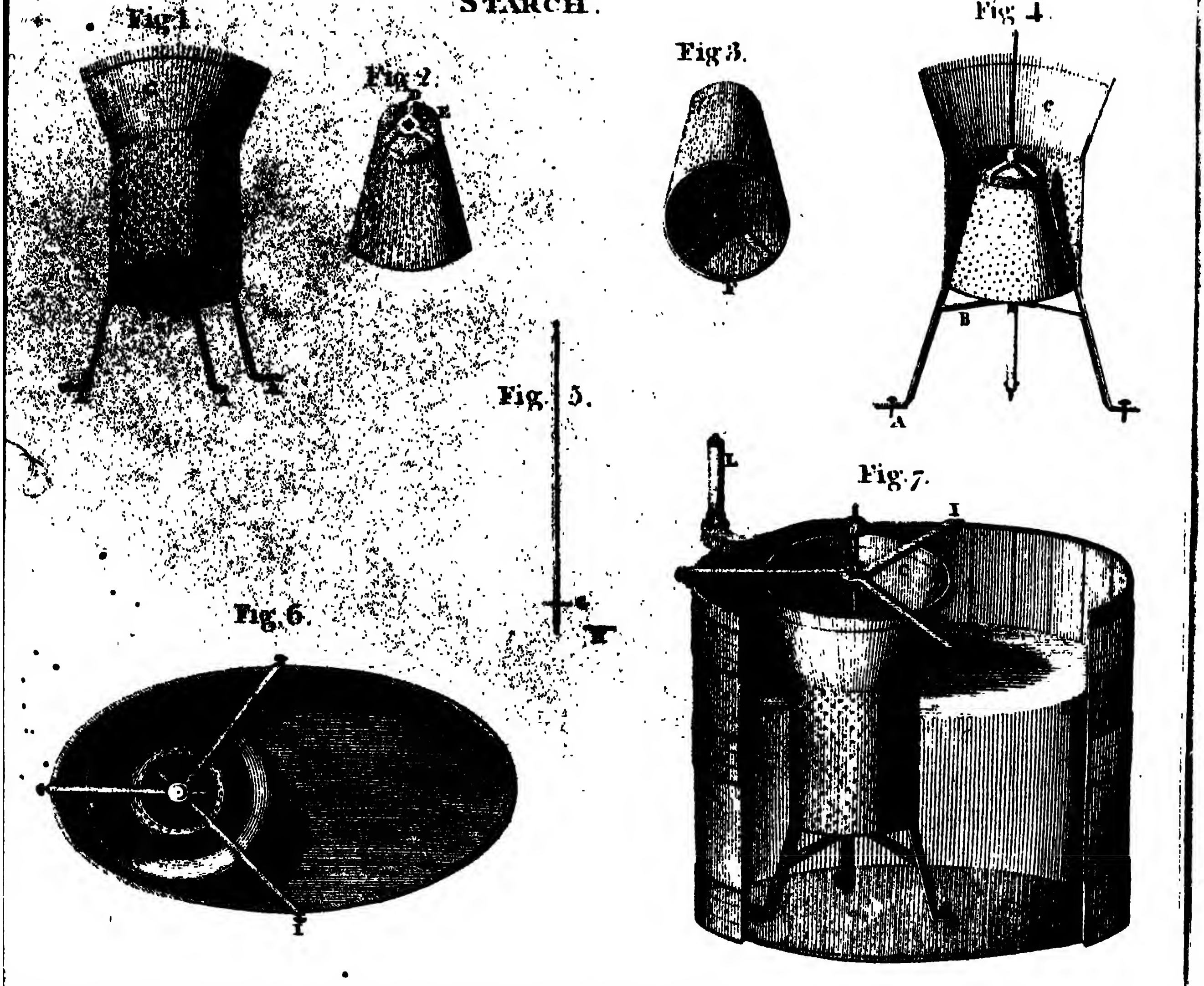
Page 745. col. 1.—It was not at the York Buildings waterworks in London that the boiler burst, but in the country in an engine erected by Dr Desaguilliers. See his *Experimental Philosophy*, Vol. II. p. 489.

Page 746. col. 2.—The condensation requires more cold water than is here allowed, as will appear by and bye; and we also suspect that the rapidity is overrated with which a great volume of steam is condensed by

REAPING SCYTHES PLATE XLII.



STARCH.



D. Lizars Sculpt.

by the cold surface of a vessel. We are well informed that Mr Watt was much disappointed in his expectations from a construction in which this mode of condensation was adopted. The condenser employed by Mr Cartwright (see *Phil. Mag.*) was one of the very first thought of and tried for this purpose, and was given up, as well as all others on the same principle; and the immediate contact of cold water was preferred as incomparably more effective. The great superiority of the capacity of water for heat is now well known. It is true, that when we employ an extensive cold surface of the condenser, this surface is kept cold by the water round it; and therefore we still avail ourselves of this great avidity of water for heat. But this water must act through the intervention of the vessel; and the substance of the vessel does not convey heat to the surrounding water in an instant.

Page 749. col. 2.—No distinct experiment shews so great an expansion of water, when converted into steam at the temperature 212°; and under the pressure of the air Mr Watt never found it more than 1800 times rarer than water.

Page 753. col. 1.—The heat expended in boiling off a cubic foot of water is about six times as much as would bring it to a boiling heat from the medium temperature (55°) in this climate.

Page 758. col. 2.—The quantity of water necessary for injection may be determined on principle, at least for an engine having a separate condenser. Every cubic foot of common steam produces about an inch of water when condensed, and contains about as much latent heat as would raise 1100 inches of water one degree. This steam must not only be condensed, but must be cooled to the temperature of the hot well; therefore as many inches of cold water must be employed as will require all this heat to raise it to the temperature of the hot well. Therefore let x be the cubic feet of steam, or capacity of the cylinder, and let y be the inches of cold water expended in condensing it. Let a be the difference between 212° and the temperature of the hot well, and b the difference between the temperature of the well and the injection cistern. We have $yb = x \times \overline{1100 + a}$, or $y = \frac{\overline{1100 + a} \times x}{b}$.

Thus, if the temperature of the hot well be 100° (and it should never be higher, if we would have a tolerable vacuum in the cylinder), and that of the injection cistern be 50°, we have $a = 112$, and $b = 50$, and $y = \frac{1212}{50} x, = 24{,}24\, x$, or $24\frac{1}{4}\, x$; that is, every foot of the capacity of the cylinder, or every inch of water evaporated from the boiler, requires more than 24 inches of water to condense the steam. A wine pint for every inch of water boiled off, or every cubic foot of capacity of the cylinder, may be kept in mind, as a large allowance. Or, more exactly, if the engine be in good order, and the injection water as low as 50°, and the hot well not above 100°, we may allow 25 gallons of injection for one gallon of water boiled off. This greatly exceeds the quantity mentioned in the case of a good Newcomen's engine, the cylinder of which contained almost 30 cubic feet of steam. And this circumstance shews the superiority of the engine with a separate condenser. The injection of Newcomen's engine had been adjusted by experience, so as to make the best compensation for the unavoidable waste in the cylinder. We presume that this machine was not loaded above eight pounds per inch, more likely with seven; whereas Watt's engine, working in the condition now described, bears a load not much below twelve, making at least twelve strokes per minute.

This is not a matter of mere curiosity; it affords a very exact rule for judging of the good working order of the engine. We can measure with accuracy the water admitted into the boiler during an hour, without allowing its surface to rise or fall, and the water employed for injection. If the last be below the proportion now given (adapted to the temperatures 50 and 100°), we are certain that steam is wasted by leaks, or by condensation in some improper place. The rule is not strictly conformable to the latent heat of steam which balances the atmosphere, 1100° being somewhat too great a value. It is accommodated to the actual performance of Watt's engines, when in their best working condition.

It is evident that it is of great importance to have the temperature of the hot well as low as possible; because there always remains a steam in the cylinder, of the same, or rather higher temperature, possessing an elasticity which balances part of the pressure on the other side of the piston, and thus diminishes the power of the engine. This is clearly seen by the barometer, which Mr Watt applies to many of his best engines, and is a most useful addition for the proprietor. It shews him, in every moment, the state of the vacuum, and the real power of his engine, and tells him when there are leaks by which air gets in.

Page 762. cols. 1. 2.—Mr Watt's first experiment was not exactly as here related, but much more analogous to the present form of his engine. The condenser was a cylinder of tinplate, fitted with a piston, which was drawn up from the bottom to the top, before the eduction cock was opened. Without this previous rarefaction in the condenser, there was no inducement for the steam to take this course, unless it were made much stronger than that of ordinary boiling water.

The description of the first form of the engine is also faulty, by the omission of a valve immediately below the eduction pipe. This valve is shut along with the valve I, to prevent the steam, which should then go into the lower part of the cylinder, from also going down into the condenser. This is not absolutely necessary, but its advantage is evident.

Page 766. col. 1.—This form of the engine was very early put in practice by Mr Watt—about the year 1775. The small engine at Mr Boulton's works at Soho was erected in 1776; and the engine at Shadwell waterworks, one of the best yet erected, had been working some time when we saw it in 1778. We mention this, because we have been told that Mr Hornblower puts in some claim to priority in this invention. We do not think that Mr Hornblower erected any of his engines before 1782; and as Mr Hornblower was, we believe, working with Boulton and Watt before that time, we think it fully more probable that he has in this respect profited by the instruction of such intelligent employers. We may also observe, that Mr Watt employed the same contrivance which we have described with much approbation in p. 772. *Encycl.* for keeping

 the

Steel

the collar round the piston rods steam and air tight. He found them effectual, but that they required more attention for keeping them in fit condition than the usual mode of packing. He made a similar packing for the piston, and with a similar result.

Page 769. col. 1. 2.—Mr Boulton estimates the performance of the engines in the following manner. Seeing that the great expence of the engine is the consumption of fuel, he makes this the standard of computation, and estimates the performance by the work which he *engages* to perform by the consumption of one bushel of good Newcastle coal, London measure, or containing 84 lbs without regard to the time in which this bushel is expended. This depends on the size of the engine.

The burning one bushel of coal will,

1. Raise 30 million pounds one foot high.
2. It will grind and dress 11 bushels of wheat.
3. It will slit and draw into nail rods 5 cwt. of iron.
4. It will drive 1000 cotton spindles, with all the preparation machinery, with the proper velocity.
5. It is equivalent to the work of ten horses.

The general performance of the double stroke expansive engines is somewhat beyond this; and their performance in cotton spinning, or as compared with horse work, is much under rated. The first estimation is without ambiguity. Suppose the engine of such a size as to consume a bushel of coals per hour. This will be found equivalent to raising 97 wine hogsheads of water ten feet high in a minute, which ten stout draught horses cannot do for a quarter of an hour together. They can raise 60 in that time, and work at this rate eight or perhaps ten hours from day to day.

Mr Watt finds that, with the most judiciously constructed furnaces, it requires eight feet of surface of the boiler to be exposed to the action of fire and flame to boil off a cubic foot of water in an hour, and that a bushel of coals so applied will boil off from eight to twelve cubic feet.

Boulton and Watt now make steam-engines equivalent in power to one or two horses. The cylinder and whole machinery does not occupy more room than a fine lady's working table, standing in a square of about 2½ feet, and about 5 feet high.

STEEL (see that article *Encycl* and CHEMISTRY, n° 114 *Suppl.*) is composed of iron and carbon. In addition to the old proofs which we had of this fact, it occurred to *Morveau*, alias *Guyton*, to attempt to convert soft iron into steel, by using the diamond instead of charcoal in the process of cementation. This expensive experiment, which was suggested by M. Clouet, was made, by inclosing within a small crucible of very soft iron a diamond, and shutting up the crucible by a stopper well adjusted. This crucible of iron, with its contents, was placed, without the addition of any surrounding matter, in a very small Hessian crucible, and the latter in a second crucible of the same earth; but the space between the two latter crucibles was filled with siliceous sand, free from all ferruginous particles. In the last place, the large crucible was luted with earth arising from pounded crucibles and unbaked clay, and the whole was exposed about an hour to a three blast forge fire. When the whole was cooled, the iron was found in the interior Hessian crucible converted into a solid ingot of cast steel. Thus the diamond disappeared by the affinity which iron exercised on it by the help of the high temperature to which they were both exposed, in the same manner as a metal disappears in the alloy of another metal. The diamond therefore furnished here the same principle as carbon, since the product of the union has the same properties.

The conversion into steel could not be doubted. The ingot having been polished on a lapidary's wheel, a drop of weak nitrous acid immediately produced a dark-grey spot, absolutely like that exhibited on English cast steel, and on cast steel produced by the process of C. Clouet. Those who have often tried steel by this kind of proof, long ago pointed out by Rinmann, had occasion to remark, that the spot of cast steel, tho' very sensible, is, however, less black than that of steel made by cementation, which depends perhaps on the different degree of oxydation of the carbon which they have taken in.

The process of M. Clouet here mentioned, for producing cast steel, consists in nothing more than throwing a quantity of glass into the mass of iron and charcoal during the formation of the former into steel. The same chemist has ascertained that iron, during its conversion into steel, absorbs 0.2013 of its weight of carbon; and that the affinity of iron for carbon is so strong, that, at a white heat, it is capable of decomposing carbonic acid gas. This he proved by the following experiment.

If six parts of iron be mixed with four parts of a mixture composed of equal quantities of carbonat of lime and clay, and kept in a crucible at a white heat, for an hour or longer, according to the quantity, the iron will be converted into steel. The decomposition of carbonic acid is evidently the consequence of a compound affinity; part of the iron combining with the carbon, and another part with the oxygen of the carbonic acid gas. Accordingly the commissioners, who were appointed to examine the process, remark, that a quantity of oxyd of iron was always mixed with the melted earthy substance, which was separated from the steel.

STEEVENS (George), the most successful of all the editors and commentators of Shakespeare, was born 1735. Of his parents we know nothing, but that they seem to have been in circumstances which may be deemed affluent. George received the rudiments of his classical education at Kingston-upon-Thames, under the tuition of Dr Woodeson and his assistants; and had for a companion at that school Gibbon the historian. From Kingston he went to Eton, whence, after some years, he was admitted a fellow-commoner of King's College, Cambridge; but with the course of his studies in the university we are not acquainted. If we might hazard a conjecture, from the manner in which he employed his riper years, we should suppose that he had little relish for those mathematical speculations which in Cambridge lead to academical honours. After he left the university, he accepted a commission in the Essex militia on its first establishment: and he spent the latter years of his life at Hampstead in almost total seclusion from the world; seldom mixing with society but in the shops of booksellers, in the Shakespeare Gallery, or in the morning *conversations* of Sir Joseph Banks. He died January 1800.

This

Steevens.

This is a very meagre account of the incidents which must have taken place in the life of a man so conspicuous in the republic of letters; but we have had no opportunity of improving it. His character, as drawn in the Monthly Magazine, believing it to be just, we shall adopt, as it will supply in some degree the defects of our narrative.

Though Mr Steevens is known rather as a commentator than as an original writer; yet, when the works which he illustrated, the learning, sagacity, taste, and general knowledge which he brought to the task, and the success which crowned his labours, are considered, it would be an act of injustice to refuse him a place among the first literary characters of the age. Adorned by a versatility of talents, he was indeed eminent both by his pen and his pencil. With the one there was nothing which he could not compose, and with the other there was nothing which he could not imitate so closely, as to leave a doubt which was the original and which the copy. But his chief excellence lay in his critical knowledge of an author's text; and the best specimen of his great abilities is his edition of Shakespeare, in which he has left every competitor far behind him. He had, in short, studied the age of Shakespeare, and had employed his persevering industry in becoming acquainted with the writings, manners, and laws of that period, as well as the provincial peculiarities, whether of language or custom, which prevailed in different parts of the kingdom, but more particularly in those where Shakespeare passed the early years of his life. This store of knowledge he was continually increasing, by the acquisition of the rare and obsolete publications of a former age, which he spared no expence to obtain; while his critical sagacity and acute observation were employed incessantly in calling forth the hidden meanings of the great dramatic bard, from their covert, and consequently enlarging the display of his beauties. This advantage is evident from his last edition of Shakespeare, which contains so large a portion of new, interesting, and accumulated illustration. In the preparation of it for the press, he gave an instance of editorial activity and perseverance, which is without example. To this work he devoted solely, and exclusively of all other attentions, a period of 18 months; and during that time he left his house every morning at one o'clock with the Hampstead patrole, and proceeded, without any consideration of the weather or the season, to his friend Mr Isaac Reed's chambers, in Barnard's Inn, where he was allowed to admit himself, and found a room prepared to receive him, with a sheet of the Shakespeare letter press ready for correction. There was every book which he might wish to consult; and to Mr Read he could apply, on any doubt or sudden suggestion, as to a man whose knowledge of English literature was perhaps equal to his own. This nocturnal toil greatly accelerated the printing of the work; as while the printers slept the editor was awake; and thus, in less than twenty months, he completed his last splendid edition of Shakespeare, in fifteen large octavo volumes; an almost incredible labour, which proved the astonishing energy and persevering powers of his mind.

That Mr Steevens contented himself with being a commentator, arose probably from the habits of his life, and his devotion to the muse, with which his own will descend to the latest posterity. It is probable that many of his *jeux d'esprit* might be collected: there is a poem of his in Dodsley's Annual Register, under the title of *The Frantic Lover*, which is superior to any similar production in the English language. Mr Steevens was a classical scholar of the first order. He was equally acquainted with the belles lettres of Europe. He had studied history, ancient and modern, but particularly that of his own country. He possessed a strong original genius, and an abundant wit; his imagination was of every colour, and his sentiments were enlivened with the most brilliant expressions. His colloquial powers surpassed those of other men. In argument he was uncommonly eloquent; and his eloquence was equally logical and animated. His descriptions were so true to nature, his figures were so finely sketched, of such curious selection, and so happily grouped, that he might be considered as a speaking Hogarth. He would frequently, in his sportive and almost boyish humours, condescend to a degree of ribaldry but little above O'Keefe—with him, however, it lost all its coarseness, and assumed the air of classical vivacity. He was indeed too apt to catch the ridiculous, both in characters and things, and indulge an indiscreet animation wherever he found it. He scattered his wit and his humour, his gibes and his jeers, too freely around him, and they were not lost for want of gathering.

Mr Steevens possessed a very handsome fortune, which he managed with discretion, and was enabled by it to gratify his wishes, which he did without any regard to expence, in forming his distinguished collections of classical learning, literary antiquity, and the arts connected with it. His generosity also was equal to his fortune; and though he was not seen to give eleemosynary sixpences to sturdy beggars or sweepers of the crossings, few persons distributed banknotes with more liberality; and some of his acts of pecuniary kindness might be named, which could only proceed from a mind adorned with the noblest sentiments of humanity. He possessed all the grace of exterior accomplishment, acquired at a period when civility and politeness were characteristics of a gentleman.

He has bequeathed his valuable Shakespeare, illustrated with near 1500 prints, to Lord Spencer; his Hogarth perfect, with the exception of one or two pieces, to Mr Windham; and his corrected copy of Shakespeare, with 200 guineas, to his friend Mr Read.

Stereometer.

STEREOMETER, an instrument lately invented in France for measuring the volume of a body, however irregular, without plunging it in any liquid. If the capacity of a vessel, or, which is the same thing, the volume of air contained in that vessel, be measured, when the vessel contains air only, and also when the vessel contains a body whose volume is required to be known, the volume of air ascertained by the first measurement, deducting the volume ascertained by the second, will be the volume of the body itself. Again, if it be admitted as a law, that the volume of any mass of air be inversely as the pressure to which it is subjected, the temperature being supposed constant, it will be easy to deduce, from the mathematical relations of quantity, the whole bulk, provided the difference between the two bulks under two known pressures be obtained by experiment.

Let it be supposed, for example, that the first pressure is double the second, or, which follows as a consequence,

quence, that the ſecond volume of the air be double the firſt, and that the difference be fifty cubic inches, it is evident that the firſt volume of the air will likewiſe be fifty cubic inches. The ſtereometer is intended to aſcertain this difference at two known preſſures.

Plate XLIII.

The inſtrument is a kind of funnel AB (fig. 1.), compoſed of a capſule A, in which the body is placed, and a tube B as uniform in the bore as can be procured. The upper edge of the capſule is ground with emery, in order that it may be hermetically cloſed with a glaſs cover M ſlightly greaſed. A double ſcale is paſted on the tube, having two ſets of graduations; one to indicate the length, and the other the capacities, as determined by experiment.

When this inſtrument is uſed, it muſt be plunged in a veſſel of mercury with the tube very upright, until the mercury riſes within and without to a point C of the ſcale. See fig. 2.

The capſule is then cloſed with the cover, which being greaſed will prevent all communication between the external air and that contained within the capſule and tube.

In this ſituation of the inſtrument, in which the mercury ſtands at the ſame height within and without the tube, the internal air is compreſſed by the weight of the atmoſphere, which is known and expreſſed by the length of the mercury in the tube of the common barometer.

The inſtrument is then to be elevated, taking care to keep the tube conſtantly in the vertical poſition. It is repreſented in this ſituation, fig. 2. ſecond poſition. The mercury deſcends in the tube, but not to the level of the external ſurface, and a column DE of mercury remains ſuſpended in the tube, the height of which is known by the ſcale. The interior air is therefore leſs compreſſed than before, the increaſe of its volume being equal to the whole capacity of the tube from C to D, which is indicated by the ſecond ſcale.

It is known therefore that the preſſures are in proportion to the barometrical column, and to the ſame column diminiſhed by the ſubtraction of DE. And the bulks of the air in theſe two ſtates are inverſely in the ſame proportion; and again the difference between theſe bulks is the abſolute quantity left void in the tube by the fall of the mercury; from which data, by an eaſy analytical proceſs, the following rule is deduced: Multiply the number which expreſſes the leſs preſſure by that which denotes the augmentation of capacity, and divide the product by the number which denotes the difference of the preſſures. The quotient will be the bulk of the air when ſubject to the greater preſſure.

To render this more eaſy by an example, ſuppoſe the height of the mercury in the barometer to be 78 centimetres, and the inſtrument being empty to be plunged in the mercury to the point C. It is then covered, and raiſed until the ſmall column of mercury DE is ſuſpended, for example, at the height of ſix centimetres. The internal air, which was at firſt compreſſed by a force repreſented by 78 centimetres, is now compreſſed only by a force repreſented by 78—6, or 72 centimetres.

Suppoſe it to be obſerved, at the ſame time, by means of the graduations of the ſecond ſcale, that the capacity of the part CD of the tube which the mercury has quitted is two cubic centimetres. Then by the rule $\frac{72}{6} \times 2$ give 24 cubical centimetres, which is the volume of the air included in the inſtrument when the mercury roſe as high as C in the tube.

The body of which the volume is to be aſcertained muſt then be placed in the capſule, and the operation repeated. Suppoſe, in this caſe, the column of mercury ſuſpended to be eight centimetres, when the capacity of the part CD of the tube is equal to two centimetres cube. Then the greateſt preſſure being denoted by 78 centimetres, as before, the leaſt will be 70 centimetres, the difference of the preſſures being 8, and the difference of the volumes two cubical centimetres. Hence $\frac{70}{8} \times 2$ gives the bulk of the included air under the greateſt preſſure 17,5 cubic centimetres. If therefore 17,5 centimetres be taken from 24 centimetres, or the capacity of the inſtrument when empty, the difference 6,5 cubic centimetres will expreſs the volume of the body which was introduced. And if the abſolute weight of the body be multiplied by its bulk in centimetres, and divided by the abſolute weight of one cubic centimetre of diſtilled water, the quotient will expreſs the ſpecific gravity of the body in the common form of the tables where diſtilled water is taken as unity, or the term of compariſon.

After this deſcription and explanation of the uſe of his inſtrument, the author proceeds with the candour and acuteneſs of a philoſopher to aſcertain the limits of error in the reſults; an object ſeldom ſufficiently attended to in the inveſtigation of natural phenomena. From his reſults it appears, that with the dimenſions he has aſſumed, and the method preſcribed for operating, the errors may affect the ſecond figure. He likewiſe gives the formulæ by means of which the inſtrument itſelf may be made to ſupply the want of a barometer in aſcertaining the greateſt preſſure. He likewiſe adverts to the errors which may be produced by change of temperature. To prevent theſe as much as poſſible, the actual form of the inſtrument and arrangements of its auxiliary parts are ſettled, as in fig. 3. by which means the approach of the hand near the veſſel and its tube is avoided. In this figure the vertical poſition of the tube is ſecured by the ſuſpenſion of the veſſel, and a perforation in the table through which the tube paſſes. The table itſelf ſupports the capſule in its firſt poſition, namely, that at which the cover is required to be put on.

Mr Nicholſon, from whoſe Journal this abſtract is immediately taken, ſuppoſes, with great probability, that the author of the invention had not finiſhed his meditations on the ſubject, when the memoir giving an account of it was publiſhed. If he had, ſays the ingenious journaliſt, it is likely that he would have determined his preſſures, as well as the meaſures of bulk, by weight. For it may be eaſily underſtood, that if the whole inſtrument were ſet to its poſitions by ſuſpending it to one arm of a balance at H (fig. 3.), the quantity of counterpoiſe, when in equilibrio, might be applied to determine the preſſures to a degree of accuracy much greater than can be obtained by linear meaſurement.

STEWART-DENHAM (Sir James) was born at Edinburgh on the 10th of October, O. S. in the year 1713. His father was Sir James Stewart of Goodtrees, Bart. Solicitor-general for Scotland; and his mother

ther was Anne, daughter of Sir Hugh Dalrymple of North Berwick, Bart. president of the college of justice.

The first rudiments of his education he received at the grammar-school of North-Berwick, which at the time of his father's death he quitted at the age of fourteen, with the reputation of being a good scholar, but without any extraordinary advancement in knowledge.

It is remarkable, that many men who have been singularly useful to society have not shewn early symptoms of the greatness of their intellectual powers. A great understanding must be the offspring of happy organization in a healthy body, with co-operation of time, of circumstance, and of institution, without being forced into prematurity by excessive cultivation. This holds with respect to the growth and perfection of every creature; and the truth appears remarkable with respect to our own species, because we are apt to mistake the flimsy attainments of artificial education for the steady and permanent foundations of progressive knowledge.

From the school of North-Berwick Sir James was sent to the university of Edinburgh, where he continued until the year 1735, when he passed advocate before the Court of Session, and immediately afterwards went abroad to visit foreign countries. He was then in the 22d year of his age, had made himself well ac- [illegible] the Roman law and history, and the municipal law of Scotland. He had likewise maturely studied the elements of jurisprudence; was versed in the general, as well as the particular, politics of Europe; and was bent upon applying his knowledge to the investigation of the state of men and of manners in other nations, with a view to promote the benefit of his own, and to confirm himself in the love of a free constitution of government, by contemplating the baneful effects of unlimited monarchy in Germany, Italy, and Spain, and of extravagant attachment to a king and nobility, to war, and to pernicious splendour in France.

He travelled first, however, into Holland, with a view to study the constitution of the empire before he should visit Germany, and to attend some of the lectures of the most eminent professors at Utrecht and Leyden, on public law and politics. From thence he passed into Germany, resided about a year in France, travelled thro' some part of Spain, where he had a fever, that obliged him, for his perfect recovery from its effects, to go by the advice of his friends to the sea-coast of the lovely province of Valencia; thence returning, he crossed the Alps, and by Turin made the tour of Italy, where chiefly at Rome and Florence he resided till the beginning of the year 1740; when, having spent five years on his travels, he returned to Scotland, and married the Lady Frances Wemyss, eldest daughter of the Earl of Wemyss, about two years after his return.

A few months after his marriage the representation of the county of Mid-Lothian became vacant, by the member being made a lord of trade and plantation. The candidates were the late member and Sir John Baird of Newbyth. On the day of election Mr Dundas of Arniston, one of the senators of the college of justice, was chosen preses of the meeting; and some how or other omitted to cause the name of Sir James Stewart to be called on the roll of freeholders. For this illegal use of his temporary power, Sir James commenced a suit against the president; and resuming the gown as an advocate, pleaded his own cause with great energy and eloquence, and with the applause of the bench, the bar, and the public. This called Lord Arniston from the bench to plead in his own defence at the bar; and Sir James could not have been opposed to an antagonist better qualified to call forth all his powers; for that judge is talked of at this day in Edinburgh as the profoundest lawyer and the ablest pleader that ever graced the Scottish bench or the Scottish bar.

With the issue of this contest we are not acquainted; but it drew upon Sir James Stewart very general attention, and convinced the public, that had he continued at the bar, he must have risen rapidly to the head of his profession. On his travels, however, he had contracted friendships with Lord Marischal, and other eminent men, attached to the pretensions of the royal family of Stuart, and had received flattering attentions from the Pretender to the British throne; the impression arising from which, added to the irritations of his controversy with the powerful party in Scotland attached to the court, led him, unadvisedly, into connections with the movers of the rebellion in 1745.

As he was by far the ablest man of their party, the Jacobites engaged him to write the Prince Regent's manifesto, and to assist in his councils. Information having been given of his participation in these affairs, he thought it prudent, on the abortion of this unhappy attempt, to leave Britain; and by the zeal, it is said, of Arniston, he was excepted afterwards from the bill of indemnity, and rendered an exile from his country.

He chose France for his residence during the ten first years of his banishment, and was chiefly at Angoulesme, where he superintended the education of his son; from thence he went to Tubingen in Suabia, for the benefit of its university, in prosecution of the same dutiful and laudable design; but in the end of the war 1756, having been suspected by the court of Versailles of communicating intelligence to the court of London, he was seized at Spa, and kept some time in confinement; from which being liberated, after the accession of the present king of Great Britain, he came, by toleration, to England, and resided at London, where he put the last hand to his System of Political Economy, the copy-right of which he sold to Andrew Millar; and being permitted to dedicate this work to the king, he applied for a *noli prosequi*, which, after some malicious objections, he obtained, and had the comfort of returning to his family estate in Scotland.

Having nothing professional to do during his long residence in France, the active mind of Sir James was occupied in study. His book on the Principles of Political Economy contains most of the fruits of it. He turned himself, in the intervals of leisure, to consider the resources of France, that he might the better compile that part of his great work which was to treat of revenue and expenditure. It was by studying the language of the finances, without which nobody can ask a proper question concerning them, so as to be understood, that he attained his great purpose.

As soon as he could ask questions properly, he applied in familiar conversation to the intendants and their substitutes in the provinces where he resided, whom he found extremely desirous to learn the state of the British finances, under the branches of the land-tax, customs, excise, and other inland duties. This led him to compare

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compare the ſtate of the two nations. The information he gave was an equivalent for the information he received; curioſity balanced curioſity, each was ſatisfied and informed. The department of the intendants in France was confined to the taxes which compoſed the *recettes generales*, namely, the *taille*, the *capitation*, and the *vingtiemes*, or *vingtiemes*. All the intendants had been *Maitres des Requetes*, bred at Paris, and could not fail to have much knowledge of the general *fermes* and other branches of the revenue. He carefully noted down at all times the anſwers he got; and when he came to reſide at Paris, he obtained more ample information, both from the gentlemen of the revenue, and from perſons of the parliament of Paris, who to the number of 25 had been for 15 months exiled in the province where he had ſo long reſided at Angouleſme.

With theſe advantages, with much ſtudy and attention to arrangement, he was enabled to compoſe the ſixth chapter of the fourth part of the fourth book of his Syſtem of Political Economy; a portion of that great work well worthy the attention of thoſe who wiſh to know the ſtate of France in reſpect of revenue under the old government.

Although Sir James Stewart's leiſure, during the firſt ten years of his exile, was chiefly employed in ſocial intercourſe with the moſt learned, elegant, and poliſhed characters in France, who delighted in the converſation and friendſhip of a man who poſſeſſed at once immenſe information, on almoſt every ſubject, important or agreeable to ſociety, and the talent of clearly and beautifully expreſſing his ſentiments in flowing and animated converſation; yet he did not allow the pleaſures of the circle and of the table to blunt the fine feelings of a man of genius and ſcience. The labour of collecting materials for his great political work was oppreſſive, and he relieved himſelf with various enquiries, ſuited to the exalted ambition of his cultivated underſtanding, while he turned the charms of converſation to the permanent delight of his aſſociates and of poſterity. The motto of Apelles, "*Nulla dies ſine linea*," was the emblem of his employment; and it is amazing what may be done by daily attention for improvement, without appearing to abſtract any extraordinary time from the common offices and rational pleaſures of ſociety.

In the beginning of the year 1755, Sir James wrote his Apology, or Defence of Sir Iſaac Newton's Chronology, which at that time he intended to publiſh, but was prevented by other engagements. It was communicated to ſeveral perſons of eminence in France and Germany in MS. and produced, in the month of December that year in the "*Mercure de France*," an anſwer from M. Deſhoulieres, to which Sir James ſoon after replied.

The great Newton, applying aſtronomical and ſtatiſtical principles to the ancient chronology of Greece, had chaſtiſed the vanity of nations, and arreſted the progreſs of infidelity in delineating the hiſtory of the world. Loſt in the confuſion of exceſſive pretenſions to an antiquity beyond all meaſure, and diſguſted by the ſuperſtitious aids that were aſſumed to ſupport theſe pretenſions among ancient nations, the revivers of learning in Europe, during the laſt and the preceding century, turmoiled themſelves with controverſies between the comparative merits of the ancients and moderns; and the abettors of the latter, entrenching themſelves behind the falſehoods of the ancients, on the ſcope of their remote hiſtory, gave the lie to all antiquity, and in deſpair plunged themſelves into the ocean of ſcepticiſm.

Happy had it been for ſociety if this ſcepticiſm had confined itſelf to the hiſtory of ancient nations in general: but the ſame ſpirit, taking diſguſt at the horrors of Chriſtian ambition and bigotry, and contemplating with deriſion the ridiculous legends of modern miracles, gave the lie to all religious ſcripture of the Jews and Chriſtians, and attempted to baniſh divine intelligence, the ſuperintending providence of Deity, and the true dignity of the human ſpecies, from the face of the earth!

It was a noble undertaking, therefore, in Sir James, to attempt to diſperſe this miſt of error, by diſpaſſionately and ſcientifically explaining and ſupporting the chronology of Sir Iſaac Newton. He has done it with great preciſion and effect; and it is a book well worth the peruſal of thoſe who wiſh to read ancient hiſtory with improvement, or to prevent themſelves from being bewildered in the mazes of modern conjecture. It was printed in 4to at Franckfort on the Maine, for John Bernard Eichemberg the Elder, in 1757.

In the year 1758, and the following, the Britiſh Houſe of Commons took up the conſideration of a ſtatute to regulate a general uniformity of weights and meaſures throughout the united kingdoms, which had been ſo often unſucceſsfully attempted.

This called the attention of Sir James, not only to the inveſtigation of the particular ſubject that engaged that of the Houſe of Commons, but to deviſe a method of rendering an uniformity of weights and meaſures univerſal. He thought the cauſe of former diſappointments in this uſeful purſuit had been the miſtaken notion that one or other of our preſent meaſures ſhould be adopted for the new ſtandard. After the plan had been relinquiſhed by the parliament of England, he digeſted his notes and obſervations on this important diſquiſition into the form of an epiſtolary diſſertation, which he tranſmitted to his friend Lord Harrington, and reſolved, if there had been a congreſs aſſembled, as was once propoſed, to adjuſt the preliminaries of the general peace in 1763, to have laid his plan before the miniſters of the different nations, who were to prepare that ſalutary pacification of the contending powers.

This epiſtolary diſſertation Sir James afterwards reduced at Coltneſs, in the year 1777, into a form more proper for the public eye, and ſent a corrected copy to a friend, reſerving another for the preſs, which was printed 1790 for Stockdale in Piccadilly.

In this tract the author ſhews, from the ineffectual attempts that have been made to alter partially, by innovation, the ſtandards of meaſures or weights, that the effectual plan to be adopted, is to depart entirely from every meaſure whatſoever now known, and to take, *ad libitum*, ſome new maſs inſtead of our pound, ſome new length inſtead of our ell, ſome new ſpace inſtead of our acre, and ſome new ſolid inſtead of our gallon and buſhel.

For this purpoſe Sir James propoſes as the unit a maſs to be verified with the greateſt poſſible accuracy, equal in weight to ten thouſand Troy grains. The pendulum, as it ſwings at London, to beat ſeconds of time,

Stewart. time, he proposes to be the measure of length; and after having laid down his fundamental principles, he proposes an ingenious plan for rendering their adoption universal through the whole world.

Having obtained his pardon, Sir James Stewart retired to Coltness, in the county of Lanark, the paternal estate of his family, where he turned his attention to the improvement of his neighbourhood by public works and police, and drew the first good plan for a turnpike bill, suited to the circumstances of Scotland, which has been since generally adopted. He repaired his house, planted, improved, and decorated his estate, and in social intercourse rendered himself the delight of his neighbourhood and country.

Never was there a man who, with so much knowledge, and so much energy of expression in conversation, rendered himself more delightful to his company, or was more regretted by his acquaintance when he died. Nor was the active mind of Sir James unemployed for the general benefit of his country during his retreat. He was engaged by the directors of the East India Company of England to digest a code for the regulation of the current coin of Bengal; the plan for which important regulation he printed, and received from the court of directors a handsome diamond ring, as a mark of their approbation.

He prepared for the press, but never published, an antidote to the *Système de la Nature* by Mirabeau, wherein the paralogisms and foolish reasoning of that infidel work are examined, detected, and confuted. It is written in French; and were the work of Mirabeau worth refutation, might be printed with much advantage to Sir James's reputation as a controversial writer.

This great and good man died in November 1780, and was buried at Cambusnethan, in Lanarkshire, on the [illegible] of the same month; the Duke of Hamilton and [illegible] performing the last offices to the remains of their highly valued friend, and bedewing his ashes with their tears.

For this short sketch of the principal events in the life of Sir James Stewart-Denham, we are indebted to his nephew the Earl of Buchan, who, justly proud of his relation to such a man, cannot be supposed to view all his projects, or even all his reasonings, with the cold impartiality of strangers. His plan, for instance, of a universal standard of weights and measures for the *whole world*, though certainly a grand conception, we cannot help considering as romantic and impracticable. The author indeed was sensible, that time would be requisite for its execution; and so large a portion of time, that, compared with it, a thousand years are but as one day, when compared with the ordinary life of man: but schemes of this magnitude are not for creatures so blind and weak as we are, who, when we wander to a distance beyond the limits of our narrow sphere, with the ambitious view of benefiting posterity, are almost certain to injure ourselves, without a probability of serving those for whom we dream that we are exerting our abilities. Sir James's Political Economy, however, is a very great work, which has not received half the praises to which it is entitled, and which, we suspect, provoked the envy of another great writer on similar subjects, who exerted himself privately to lessen its fame. The defence of Newton's chronology is likewise very valuable, though we certainly do not think that part of the system invulnerable, in which the great astronomer attempts to prove, that *Osiris*, *Sesostris*, and *Sesac*, are three names of the same Egyptian king. This, however, is a very trifling mistake; and the modern sciolist, who can lay hold of it to reject the whole, has certainly never read, or, if he has read, does not understand the defence of the system by Sir James Stewart.

SUBCONTRARY POSITION, in geometry, is when two equiangular triangles are so placed, as to have one common angle at the vertex, and yet their bases not parallel; consequently the angles at the bases are equal, but on the contrary sides.

SUBDUCTION, in arithmetic, the same as *Subtraction*.

ANIMAL AND VEGETABLE SUBSTANCES.

THE reader will recollect, that the article CHEMISTRY, in this *Supplement*, was divided into four parts; of which only the first three, comprehending the elements of the science, were given under the word CHEMISTRY. The *fourth part*, which was entitled an examination of bodies as they are presented to us by nature in the mineral, vegetable, and animal kingdoms,

1 Nature of the article.

naturally subdivides itself into three parts, comprehending respectively, 1. Minerals; 2. Vegetables; 3. Animals.

The first of these subdivisions, which has been distinguished by the name of MINERALOGY, we have treated of already in a former part of this Volume. As the other two subdivisions have not hitherto received any appropriate name, we have satisfied ourselves with the word SUBSTANCE, by which chemists have agreed to denote the objects which belong to these subdivisions. This name, it must be acknowledged, is not unexceptionable, but we did not consider ourselves as at liberty to invent a new one.

The present article, then, seems to divide itself into two parts: the first part comprehending *vegetable*; the second *animal* substances. But there are certain animal and vegetable substances distinguished from all others by being used as articles of clothing. It is usual to tinge these of various colours, by combining with them different colouring matters for which they have an affinity. This process, well known by the name of DYEING, is purely chemical; and as it belongs exclusively to animal and vegetable substances, it comes naturally to be examined here. We shall therefore add a *third part*, in which we shall give a view of the present state of DYEING, as far, at least, as is consistent with the nature of a supplementary article.

Division of it.

Part I. Of Vegetable SUBSTANCES.

Sugar. Vegetables, or plants, as they are also called, are too well known to require any definition. Their number is prodigious, and their variety, regularity, and beauty, are wonderful. But it is not our intention in this place either to enumerate, to describe, or to classify plants. These tasks belong to the botanist, and have been successfully accomplished by the zeal, the singular address, and the indefatigable labour of Linnæus and his followers.

4 Chemical examination of vegetables.

It is the business of the chemist to analyse vegetables, to discover the substances of which they are composed, to examine the nature of these substances, to investigate the manner in which they are combined, to detect the processes by which they are formed, and to ascertain the chemical changes to which plants, after they have ceased to vegetate, are subject. Hence it is evident, that a chemical investigation of plants comprehends three particulars:

1. An account of the *substances* of which plants are composed.

2. An account of the *vegetation* of plants, as far as it can be illustrated by chemistry.

3. An account of the *changes* which plants undergo after they cease to vegetate.

We therefore divide this part into three chapters, assigning a chapter to each of these particulars.

Chap. I. Of the Ingredients of Plants.

The substances hitherto found in the vegetable kingdom, all of them at least which have been examined with any degree of accuracy, may be reduced to the following heads:

1. Sugar,	10. Camphor,
2. Starch,	11. Resins,
3. Gluten,	12. Caoutchouc,
4. Albumen,	13. Wax,
5. Gum,	14. Wood,
6. Jelly,	15. Acids,
7. Extract,	16. Alkalies,
8. Tan,	17. Earths,
9. Oils,	18. Metals.

These shall form the subject of the following sections:

Sect. I. *Of Sugar.*

Sugar, which at present forms so important an article in our food, seems to have been known at a very early period to the inhabitants of India and China.

4 Discovery of sugar.

But Europe probably owes its acquaintance with it to the conquests of Alexander the Great. For ages after its introduction into the west, it was used only as a medicine; but its consumption gradually increased, and during the time of the Crusades, the Venetians, who brought it from the east, and distributed it to the northern parts of Europe, carried on a lucrative commerce with sugar. It was not till after the discovery of America, and the extensive cultivation of sugar in the West Indies, that its use in Europe, as an article of food, became general *.

Sugar is obtained from the *arundo saccharifera*, or *sugar cane*. The juice of this plant is pressed out and boiled in as low a temperature as possible, till the sugar precipitates in the form of confused crystals. These crystals, known by the name of *raw sugar*, are again dissolved in water, the solution is clarified, and purer crystals are obtained by a subsequent evaporation. But for the particulars of the art of manufacturing sugar, we refer the reader to the article Sugar in the *Encyclopedia*.

Sugar. 5 How obtained.

6 Its properties.

Sugar, after it has been purified, or *refined* as the manufacturers term it, is usually sold in Europe in the form of a white opake mass, well known by the name of *loaf sugar*. Sometimes also it is crystallized, and then it is called *sugar candy*.

Sugar has a very strong sweet taste; when pure it has no smell; its colour is white, and when crystallized it is somewhat transparent. It has often a considerable degree of hardness; but it is always so brittle that it can be reduced without difficulty to a very fine powder. It is not altered by exposure to the atmosphere.

It is exceedingly soluble in water. At the temperature of 48°, water, according to Mr Wenzel, dissolves its own weight of sugar. The solvent power of water increases with its temperature; when nearly at the boiling point, it is capable of dissolving any quantity of sugar whatever. Water thus saturated with sugar is known by the name of *syrup*. 7 Solubility in water.

Syrup is thick, ropy, and very adhesive; when spread thin upon paper, it soon dries, and forms a kind of varnish, which is easily removed by water. Its specific caloric, according to the experiments of Dr Crawford, is 1.086. When syrup is [illegible] crystallized, the sugar which it contains [illegible]. 8 The primitive form of these crystals [illegible] prism, whose base is a rhomb, [illegible] to its breadth as 10 to 7; and whose [illegible] proportion between the length and breadth of the base. The crystals are usually four or six-sided prisms, terminated by two sided, and sometimes by three-sided summits †.

Sugar is soluble in alcohol, but not in so large a proportion as in water. According to Wenzel, four parts of boiling alcohol dissolve one of sugar §. It unites readily with oils, and renders them miscible with water. A moderate quantity of it prevents, or at least retards, the coagulation of milk; but Scheele discovered that a very large quantity of sugar causes milk to coagulate ‖. 9 Solubility in alcohol.

Sugar absorbs muriatic acid gas slowly, and assumes a brown colour and very strong smell ‡.

Sulphuric acid, when concentrated, readily decomposes sugar; water is formed, and perhaps also acetous acid; while charcoal is evolved in great abundance, and gives the mixture a black colour, and a considerable degree of consistency. The charcoal may be easily separated by dilution and filtration. When heat is applied the sulphuric acid is rapidly converted into sulphurous acid. 10 Action of acids.

When sugar is mixed with potash, the mixture acquires a bitter and astringent taste, and is insoluble in alcohol, though each of the ingredients is very soluble in that liquid. When the alkali is saturated with sulphu- 11 Of potash.

* See Falconer's History of Sugar, Manchester Memoirs, iv. 291. and Moseley's Treatise on Sugar.

† Gillot, Ann. de Chim. xviii. 317.

§ Enc. Meth. Chim. i. 271.

‖ Scheele ii. 52. Dijon translation.

‡ Priestley, ii. 291.

Sugar

ric acid, and precipitated by means of alcohol, the sweet taste of the sugar is restored; a proof that it had undergone no decomposition from the action of the potash, but had combined with it in the state of sugar *.

* Cruickshank Roll'o on Diabetes, p. 452.

12 Of lime.

Lime boiled with sugar produces nearly the same effect as potash; when an alkali is added to the compound, a substance precipitates in white flakes. This substance is sugar combined with lime †. Sugar and chalk compose, as Leonardi informs us, a kind of cement ‡.

† Ibid.

‡ Encyc. Meth. Chim i. 271.

13 Of heat.

Sugar, when thrown upon a hot iron, melts, swells, becomes brownish black, emits air bubbles, and exhales a peculiar smell, known in French by the name of *caromel*. At a red heat it instantly bursts into flames with a kind of explosion. The colour of the flame is white with blue edges.

14 Distillation of it.

When sugar is distilled in a retort, there comes over a fluid which, at first, scarcely differs from pure water; by and bye it is mixed with pyromucous acid, afterwards some empyreumatic oil makes its appearance; and a bulky charcoal remains in the retort. This charcoal very frequently contains lime, because lime is used in refining sugar; but if the sugar, before being submitted to distillation, be dissolved in water, and made to crystallize by evaporation in a temperature scarcely higher than that of the atmosphere, no lime whatever, nor any thing else, except pure charcoal, will be found in the retort. During the distillation, there comes over a considerable quantity of carbonic acid, and carbonated hydrogen gas *. Sugar therefore is decomposed by the action of heat; and the following compounds are formed from it: Water, pyromucous acid, oil, charcoal, carbonic acid, carbonated hydrogen gas. The quantity of oil is inconsiderable; by far the most abundant product is pyromucous acid. Sugar indeed is very readily converted into pyromucous acid; for it makes its appearance always whenever syrup is raised to the boiling temperature. Hence the smell of caromel, which syrup at that temperature emits. Hence also the reason that, when we attempt to crystallize syrup by heat, there always remains behind a quantity of incrystallizable matter, known by the name of *molasses*; whereas if the syrup be crystallized without artificial heat, every particle of sugar may be obtained from it in a crystalline form †. Hence we see the importance of properly regulating the fire during the crystallization of sugar, and the immense saving that would result from conducting the operation at a low heat.

* Scopoli and Morveau, Enc. Meth. Chim. i. 269.

† Morveau, Enc. Meth. Chim. i. 266.

15 Its composition.

It follows from these facts, and from various other methods of decomposing sugar, that it is composed of oxygen, hydrogen, and carbon; for all the substances obtained from sugar by distillation may be resolved into these elements. Lavoisier has made it probable, by a series of very delicate experiments, that these substances enter into the composition of sugar in the following proportions:

64	oxygen,
28	carbon,
8	hydrogen.
100	

Of the way in which these ingredients are combined in sugar, we are still entirely ignorant. Lavoisier's conclusions can only be considered as approximations to the truth.

Sugar is considered as a very nourishing article of food. It is found most abundantly in the juice of the sugar cane, but many other plants also contain it. The juice of the acer saccharinum, or *sugar maple*, contains so much of it, that in North America sugar is often extracted from that tree *. Sugar is also found in the roots of carrot, parsnip, beet, &c. Mr Achard has lately pointed out a method of increasing the quantity of sugar in beet so much, that, according to his own account, it is at present cultivated in large quantities in Prussia, and sugar extracted from it with advantage †. Parmentier has also ascertained that the grains of wheat, barley, &c. and all the other similar seeds which are used as food, contain at first a large quantity of sugar, which gradually disappears as they approach to a state of maturity. This is the case also with peas and beans, and all leguminous seeds, and is one reason why the flavour of young peas is so much superior to that of old ones.

Starch.

16 Plants containing it.

* [illegible] ii. 64.

† Ann. de Chim xxxvi. 163.

SECT. II. *Of Starch.*

17 Method of obtaining starch.

When a quantity of wheat flour is formed into a paste, and water poured upon it till it runs off colourless, this water soon deposits a very fine whitish powder; which, when properly washed and dried, is known by the name of *starch*. When first prepared, it is of a grey colour; but the starchmakers render it white by steeping it in water slightly acidulated. The acid seems to dissolve and carry off the impurities.

Starch was well known to the ancients. Pliny informs us, that the method of obtaining it was first invented by the inhabitants of the island of Chio ‡.

‡ Lib. xviii. c. 7.

18 Its properties.

Starch has a fine white colour, and is usually concreted in longish masses; it has scarcely any smell, and very little taste. When kept dry, it continues for a long time uninjured though exposed to the air.

19 How acted on by water.

Starch does not dissolve in cold water, but very soon falls to powder. It combines with boiling water, and forms with it a thick paste. Linen dipt into this paste, and afterwards dried suddenly, acquires, as is well known, a great degree of stiffness. When this paste is left exposed to damp air it soon loses its consistency, acquires an acid taste, and its surface is covered with mould.

20 Alcohol,

Starch is so far from dissolving in alcohol, even when assisted by heat, that it does not even fall to powder.

21 Acids,

When starch is thrown into any of the mineral acids, at first no apparent change is visible. But if an attempt is made to break the larger pieces while in acids to powder, they resist it, and feel exceedingly tough and adhesive. Sulphuric acid dissolves it slowly, and at the same time a smell of sulphurous acid is emitted, and such a quantity of charcoal is evolved, that the dish containing the mixture may be inverted without spilling any of it. Indeed if the quantity of starch be sufficient, the mixture becomes perfectly solid. The charcoal may be separated by dilution and filtration. In muriatic acid starch dissolves still more slowly. The solution resembles mucilage of gum arabic, and still retains the peculiar odour of muriatic acid. When allowed to stand for some time, the solution gradually separates into two parts; a perfectly transparent straw-coloured liquid below, and a thick, muddy, oily, or rather mucilaginous substance, above. When water is poured in, the muriatic smell instantly disappears, and a strong smell is exhaled, precisely similar to that which is felt in corn-

 mills,

Gluten.

mills. Ammonia occaſions a ſlight precipitate, but too ſmall to be examined.

Nitric acid diſſolves ſtarch more rapidly than the other two acids; it acquires a green colour, and emits nitrous gas. The ſolution is never complete, nor do any cryſtals of oxalic acid appear unleſs heat be applied. In this reſpect ſtarch differs from ſugar, which yields oxalic acid with nitric acid, even at the temperature of the atmoſphere. When heat is applied to the ſolution of ſtarch in nitric acid, both oxalic and malic acid is formed, but the undiſſolved ſubſtance ſtill remains. When ſeparated by filtration, and afterwards edulcorated, this ſubſtance has the appearance of a thick oil, not unlike tallow; but it diſſolves readily in alcohol. When diſtilled, it yields acetous acid, and an oil having the ſmell and the conſiſtence of tallow *.

22 Heat.

When ſtarch is thrown upon a hot iron, it melts, blackens, froths, ſwells, and burns with a bright flame like ſugar, emitting, at the ſame time, a great deal of ſmoke; but it does not explode, nor has it the caromel ſmell which diſtinguiſhes burning ſugar. When diſtilled, it yields water impregnated with an acid, ſuppoſed to be the pyromucous, and mixed with a little empyreumatic oil. The charcoal which remains is eaſily diſſipated when ſet on fire in the open air; a proof that it contains very little earth.

Decompoſition.

Barley grain conſiſts almoſt entirely of ſtarch, not however in a ſtate of perfect purity. In the proceſs of malting, which is nothing elſe than cauſing the barley to begin to vegetate, a great part of the ſtarch is converted into ſugar. During this proceſs oxygen gas is abſorbed, and carbonic acid gas is emitted. Water, too, is abſolutely neceſſary; hence it is probable, that it is decompoſed, and its hydrogen retained †. Starch, then, ſeems to be converted into ſugar by diminiſhing the proportion of its carbon, and encreaſing that of its hydrogen and oxygen. Its diſtillation ſhews us that it contains no other ingredients than theſe three.

Subſtances containing it.

Starch is contained in a great variety of vegetable ſubſtances; moſt commonly in their ſeeds or bulbous roots; but ſometimes alſo in other parts. Mr Parmentier, whoſe experiments have greatly contributed towards an accurate knowledge of ſtarch, has given us the following liſt of the plants from the roots of which it may be extracted.

Arctium lappa,	Imperatoria oſtrutheum,
Atropa belladonna,	Hyoſcyamus niger,
Polygonum biſtorta,	Rumex obtuſifolius,
Bryonia alba,	——— acutus,
Colchicum autumnale,	——— aquaticus,
Spiræa filipendula,	Arum maculatum,
Ranunculus bulboſus,	Orchis maſcula,
Scrophularia nodoſa,	Iris pſeudacorus,
Sambucus ebulus,	—- fœtidiſſima,
———— nigra,	Orobus tuberoſus,
Orchis morio,	Bunium bulbocaſtanum.

It is found alſo nearly pure in the following ſeeds:

Oats,	Cheſnut,	Acorn,
Rice,	Horſecheſnut,	And alſo in
Maiz,	Peas,	Salop,
Millet,	Beans,	Sago.

SECT. III. *Of GLUTEN.*

WHEN wheat flour is waſhed in the manner deſcribed in the laſt ſection, in order to obtain ſtarch from it, the ſubſtance which remains, after every thing has been waſhed away which cold water can ſeparate, is called *gluten*. It was diſcovered by Beccaria an Italian philoſopher, to whom we are indebted for the firſt analyſis of wheat flour †.

25 Gluten, how obtained.

26 Its properties.

Gluten, when thus obtained, is of a grey colour, exceedingly tenacious, ductile, and elaſtic, and may be extended to twenty times its original length. When very thin, it is of a whitiſh colour, and has a good deal of reſemblance to animal tendon or membrane. In this ſtate it adheres very tenaciouſly to other bodies, and has often been uſed to cement together broken pieces of porcelain. Its ſmell is agreeable. It has ſcarce any taſte, and does not loſe its tenacity in the mouth.

27 Action of air.

When expoſed to the air, it gradually dries; and, when completely dry, it is pretty hard, brittle, ſlightly tranſparent, of a dark brown colour, and has ſome reſemblance to *glue*. It breaks like a piece of glaſs, and the edges of the fracture reſemble in ſmoothneſs thoſe of broken glaſs; that is to ſay, it breaks with a *vitreous* fracture.

28 Water.

When expoſed to the air, and kept moiſt, it ſoon putrifies; but when dry, it may be kept any length of time without alteration. It is inſoluble in water; tho' it imbibes and retains a certain quantity of it with great obſtinacy. To this water it owes its elaſticity and tenacity. When boiled in water, it loſes both theſe properties. It is ſoluble in alcohol, as Mr Vauquelin informs us ‡; and precipitated again, as Mr Fourcroy has obſerved, by pouring into the alcohol two parts of water §.

29 Acids.

Gluten is ſoluble in the three mineral acids. When nitric acid is poured on it, and heat applied, a quantity of azotic gas is emitted, as Berthollet ha[illegible] and, by continuing the heat, a quantity of oxalic acid is formed ‖.

30 Alkalies.

Alkalies diſſolve gluten when they are aſſiſted by heat. The ſolution is never perfectly tranſparent. Acids precipitate the gluten from alkalies, but it is deſtitute of its elaſticity ¶.

31 Heat.

When moiſt gluten is ſuddenly dried, it ſwells amazingly. Dry gluten, when expoſed to heat, cracks, ſwells, melts, blackens, exhales a fetid odour, and burns preciſely like feathers or horn. When diſtilled, there comes over water impregnated with ammonia and an empyreumatic oil; the charcoal which remains is with difficulty reduced to aſhes. From theſe phenomena, it is evident that gluten is compoſed of carbon, hydrogen, azot, and oxygen: perhaps alſo it contains a little lime. In what manner theſe ſubſtances are combined is unknown.

32 Its compoſition.

33 Subſtances containing it.

The only vegetable ſubſtance which has been hitherto found to contain it abundantly, is wheat flour. Vauquelin alſo found it in the fruit of the *caſſia fiſtuloris* *, and Fourcroy in the bark of a ſpecies of quinquina from St Domingo †. It probably exiſts in many other plants.

SECT. IV. *Of ALBUMEN.*

Albumen.

IF the water in which wheat flour has been waſhed in order to obtain ſtarch and gluten, according to the directions laid down in the two laſt ſections, be filtrated, and afterwards boiled, a ſubſtance precipitates in white flakes; to which Mr Fourcroy, who firſt pointed it

* *Scheele*, *Crell's Journ.* ii. 14. *Engliſh tranſlation.*

† *Cruikſhank*, *on Diabetes.*

† *Collect. Acad.* x. 1.

‡ *Ann. de Chim.* vi. 178.

§ *Ibid.* viii.

‖ *Vauquelin*, *Ibid.* vi. 275.

¶ *Fourcroy.*

* *Ibid.*

† *Ibid.* viii. 135.

Jelly. it out, has given the name of *albumen* (A), on account of its resemblance to the *white* of an egg ‡.

‡ Ann. de Chim. iii. 255.

It is evident, from the method of obtaining it, that albumen, in its natural state, is soluble in water, and

34 Properties of albumen. that heat precipitates it from that fluid in a concrete state. While dissolved in water, it has scarcely any taste; but it has the property of changing vegetable blues, especially that which is obtained from the flowers of the mallow (*malva sylvestris*), into a green §. When allowed to remain dissolved in water, it putrifies without becoming previously acid ‖.

§ Fourcroy, Ibid. 257.

‖ Ibid.

After it has been precipitated from water in a concrete state by boiling, it is no longer soluble in water as before. Alcohol also precipitates it from water precisely in the same state as when it is precipitated by heat.

When concrete albumen is dried it becomes somewhat transparent, and very like glue. In that state it is soluble in alkalies, especially ammonia *.

* Ibid.

When distilled it gives out carbonat of ammonia, a red fetid oil, and carbonated hydrogen gas; and a spungy charcoal remains behind †. From this, it is evident

35 Its composition. that albumen, like gluten, is composed of carbon, azot, hydrogen, and oxygen; but the proportions and combinations of these substances are altogether unknown.

† Ibid.

Mr Fourcroy found albumen in the expressed juice of scurvy grass, cresses, cabbage, and almost all cruciform plants. He found it, too, in a great many young and succulent plants; but never a particle in those parts of vegetables which contain an acid. He observed also that the quantity decreased constantly with the age of the plant.

SECT. V. Of Jelly.

If we press out the juice of ripe blackberries, currants, and many other fruits, and allow it to remain for some time in a state of rest, it partly coagulates into a tremulous soft substance, well known by the name of *jelly*. If we pour off the uncoagulated part, and wash the coagulum with a small quantity of water, we obtain *jelly* approaching to a state of purity.

Properties of jelly. In this state it is nearly colourless, unless tinged by the peculiar colouring matter of the fruit; it has a pleasant taste, and a tremulous consistency. It is scarcely soluble in cold water, but very soluble in hot water; and, when the solution cools, it again coagulates into the form of a jelly †. When long boiled, it loses the property of gelatinising by cooling, and becomes analagous to mucilage ‡. This is the reason that in making currant jelly, or any other jelly, when the quantity of sugar added is not sufficient to absorb all the watery parts of the fruit, and consequently it is necessary to concentrate the liquid by long boiling, the mixture often loses the property of coagulating, and the jelly, of course, is spoiled §.

† Vauquelin, Ann. de Chim. vi. 82.

‡ Ibid. 100.

§ Ann. de Chim. v. 102.

Jelly combines readily with alkalies; nitric acid converts it into oxalic acid, without separating any azotic gas ‖. When dried it becomes transparent ¶. When distilled it affords a great deal of pyromucous acid, a small quantity of oil, and scarcely any ammonia †.

‖ Ibid. vi. 282.

¶ Ibid. v. 105.

† Ibid. vi. 285.

Jelly exists in all acid fruits, as oranges, lemons, gooseberries, &c. and no albumen is ever found in those parts of vegetables which contain an acid. This circumstance has induced Fourcroy to suppose that jelly is albumen combined with an acid *: but this conjecture has not been verified by experiment; nor indeed is it probable that it ever shall; as albumen evidently contains a quantity of azot, and jelly scarcely any. The products of jelly by distillation shew that it approaches nearer than any other vegetable substance to the nature of sugar.

* Ibid. iii. 254.

SECT. VI. Of Gum.

THERE is a thick transparent tasteless fluid which sometimes exudes from certain species of trees. It is very adhesive, and gradually hardens without losing its transparency; but easily softens again when moistened

37 Gum how obtained. with water. This exsudation is known by the name of *gum*. The gum most commonly used is that which exsudes from different species of the *mimosa*, particularly the *nilotica* †. It is known by the name of *gum arabic*. Gum likewise exsudes abundantly from the *prunus avium*, or common wild cherry tree of this country.

† Salisbury, Phil. Mag. v. 241.

Gum is usually obtained in small pieces like tears, moderately hard, and somewhat brittle while cold, so that it can be reduced by pounding to a fine powder. Its colour is usually yellowish, and it is not destitute of lustre. It has no smell; its taste is insipid.

Gum undergoes no change from being exposed to the atmosphere; but the light of the sun makes it as-

38 Action of water. sume a white colour. Water dissolves it in large quantities. The solution which is known by the name of *mucilage* (B), is thick and adhesive: it is often used as a paste, and to give stiffness and lustre to linen. When spread out thin it soon dries, and has the appearance of a varnish; but it readily attracts moisture, and becomes glutinous. Water washes it away entirely. When mucilage is evaporated the gum is obtained unaltered.

39 Action of alcohol. Gum is insoluble in alcohol. When alcohol is poured into mucilage, the gum immediately precipitates; because the affinity between water and alcohol is greater than that between water and gum.

The action of alkalies and earths upon gum has not been

(A) The existence of albumen in vegetables was known to Scheele. He mentions it particularly in his paper on Milk, first published in the year 1780. See *Scheele's Works*, II. 55. Dijon edition.

(B) Hermstadt uses this word in a different sense. He makes a distinction between *gum* and *mucilage*. The solution of *gum* in water is transparent and glutinous, and can be drawn out into threads; whereas that of *mucilage* is opake, does not feel glutinous, but slippery, and cannot be drawn into threads. Gum may be separated from mucilage by the following process:

Let the gum which is supposed to be mixed with mucilage, previously reduced to a dry mass, be dissolved in as small a quantity of water as possible, and into the solution drop at intervals diluted sulphuric acid. The mucilage coagulates while the gum remains dissolved. When no more coagulation takes place, let the mixture remain at rest for some time, and the mucilage will precipitate to the bottom, and assume the consistence of jelly. Decant off the liquid part, and evaporate the mucilage to dryness by a gentle heat till it acquires the consistence of horn. *Med. and Phys. Jour.* iii. 370.

Extract. been examined. Acids do not precipitate it from mucilage ‡. The concentrated mineral acids destroy it.
‡ Vauquelin. Concentrated sulphuric acid decomposes it; water is formed, and perhaps also acetous acid; while charcoal is precipitated. Nitric acid converts it into oxalic acid; oxy muriatic acid, on the contrary, into citric acid *.

* Id. Ann de Chim vi 178. When gum is exposed to heat it softens and swells, but does not melt; it emits air bubbles, blackens, and at last, when nearly reduced to charcoal, emits a low
Of heat. blue flame. This flame appears sooner if a flaming substance be held just above the gum. After the gum is consumed, there remains a small quantity of white ashes, composed chiefly of the carbonats of lime and potass.

When gum is distilled in a retort, the products are water impregnated with a considerable quantity of pyromucous acid, a little empyreumatic oil, carbonic acid gas, and carbonated hydrogen gas. When the pyromucous acid obtained by this process is saturated with lime, a quantity of ammonia is disengaged with which that acid had been combined. The charcoal which remained in the retort leaves behind it, after incineration,
§ Cruick-shank Rollo on D. Iter a little lime, and phosphat of lime §

These experiments shew us that gum is composed of
41 Compo- hydrogen, carbon, oxygen, azot, lime, and phosphorus; but the proportions and combinations of these substances are unknown to us. Mr Cruickshank has rendered it probable that the quantity of carbon is greater, and
‖ Ibid. the quantity of oxygen less, in gum than in sugar ‖.

Gum, or mucilage, exists most abundantly in young plants, and gradually disappears as they arrive at perfection. It forms a great proportion of the leaves and roots of many eatable plants.

Sect. VII. *Of Extract.*

The word *extract* was at first applied to all those substances which were extracted from plants by means of water, and consequently included gum, jelly, and several other bodies. But of late it has been confined, by those chemists who have paid attention to the use of
42 Extract, how obtained. language, to a substance which exists in many plants, and which may be obtained by infusing *saffron* in water for some time, filtrating the infusion, and evaporating it to dryness. The residuum, after evaporation, is *extract* nearly pure ¶. It possesses the following properties:
¶ Hermbstadt.

43 Its properties. Water dissolves it in considerable quantities, especially hot water. Alcohol also dissolves it with facility. This property of being soluble both in water and alcohol has induced some chemists to give *extract* the name of *soap*. It is insoluble in sulphuric ether. These three properties are sufficient to distinguish it from every other vegetable substance *.
* Hermbstadt.

When the solution of extract in water is exposed for some time in the open air, the extract precipitates, and is now no longer soluble in water. This change is supposed to proceed from the addition of a quantity of
† Fourcroy. oxygen which it imbibes from the atmosphere †.

When oxy-muriatic acid is poured into a watery solution of extract, that substance precipitates in yellow flakes. These flakes are insoluble in water; they are insoluble also in alcohol at the temperature of 97°; but that liquid dissolves them at the temperature of 120°. They are soluble also in alkalies, and in boiling-hot
‡ Fourcroy. water they melt into a yellow mass ‡.

Extract is soluble in acids. Heat softens but does not melt it §. Tan.

It is found in a great variety of plants; but as no method of obtaining it perfectly pure has hitherto been discovered, the extracts of different plants differ somewhat from each other both in their colour and smell. § Id. Ann de Chim. viii.

Sect. VIII. *Of Tan.*

If a quantity of nut galls, coarsely powdered, be kept for some time infused in cold water, if the water be filtered, and a solution of muriat of tin be dropt into it, a copious white precipitate falls to the bottom. 44 Preparation of tan
This precipitate is to be carefully washed and diffused (for it will not dissolve) thro' a large quantity of water, and this water is to be saturated with sulphurated hydrogen gas so completely that it will not absorb any more. By this treatment the white precipitate will gradually disappear, and a brown precipitate will take its place. This brown precipitate must be separated by filtration; and the water, which has now acquired the colour and the taste of the infusion of nut galls, must be evaporated to dryness. A substance remains behind, known by the name of *tan* or *tannine*.

It was first discovered by Seguin, who pointed out some of its properties, and the method of detecting it in plants ‖. The above method of obtaining it in a state of purity was contrived by Mr Proust. Tan exists in the solution of nut galls combined with gallic acid. ‖ Nicholson's Jour. i. 271.
The oxyd of tin has a strong affinity for it. When muriat of tin is poured in, the tan combines with the oxyd, and the compound, being insoluble, falls to the bottom. Sulphur has a stronger affinity for the oxyd than tan has. Hence when sulphurated hydrogen gas is thrown upon this compound, the sulphur leaves the gas and combines with the tin; and the compound, being insoluble, falls to the bottom. The hydrogen gas escapes, and nothing remains in the water except tan.

Tan is a brittle substance, of a brown colour. It breaks with a vitreous fracture, and does not attract moisture from the air. Its taste is exceedingly astringent. It is very soluble in water. The solution is of a deep brown colour, a very astringent and bitter taste, and has the odour which distinguishes a solution of nut galls. It froths when agitated, like a solution of soap; but does not feel unctuous. Acids precipitate the tan from this solution. 45 Its properties.

Tan is still more soluble in alcohol than in water.

When the solution of tan is poured into a solution of the brown sulphat of iron, a deep blue coloured precipitate immediately appears, consisting of the tan combined with the oxyd. This precipitate, when dried, assumes a black colour. It is decomposed by acids. The green sulphat of iron is not altered by tan.

When too great a proportion of brown sulphat of iron is poured into a solution of tan, the sulphuric acid, set at liberty by the combination of the iron and tan, is sufficient to redissolve the precipitate as it appears; but the precipitate may easily be obtained by cautiously saturating this excess of acid with potass. When the experiment is performed in this manner, all the red sulphat of iron which remains in the solution undecomposed is converted into green sulphat. Mr Proust, to whom we are indebted for almost every thing yet known concerning the properties of tan, supposes that this change is produced

Camphor. produced by the tan abforbing oxygen from the iron. This may very poffibly be the cafe; but his experiments are infufficient to prove that it is. The fame change takes place if red oxyd be mixed with a confiderable excefs of fulphuric acid, and diluted with water.

Tan combines readily with oxygen. When oxy muriatic acid is poured upon it, its colour deepens, and it lofes all its peculiar characters *.

* Prouft, Ann. de Chim. xxv. 225.

Tan exifts in almoft all thofe vegetable fubftances which have an aftringent tafte. It is almoft conftantly combined with gallic acid. The following table, drawn

46 Plants containing it up by Mr Biggin †, though the rule which the author followed in making his experiments precluded rigid accuracy, will ferve to give fome idea of the proportions of tan which exift in different plants:

† Phil. Tranf. 1799.

	Prop. of Tan.		Prop. of Tan.
Elm - -	2,1	Sallow - -	4,6
Oak cut in winter -	2,1	Mountain afh -	4,7
Horfe chefnut -	2,2	Poplar - -	6,0
Beech - - -	2,4	Hazel - -	6,3
Willow (boughs)	2,4	Afh - -	6,6
Elder - - -	3,0	Spanifh chefnut -	9,0
Plum tree -	4,0	Smooth oak - -	9,2
Willow (trunk) -	4,0	Oak cut in fpring	9,6
Sycamore - -	4,1	Huntingdon or Leicefter willow	10,1
Birch - -	4,1		
Cherry tree - -	4,2	Sumach - -	16,2

SECT. IX. Of Oils.

There are two [illegible] of oils; namely, *fixed* and *volatile*, both of which are found abundantly in plants.

1. Fixed oil is found in the feeds of many plants, efpecially of the olive, beech, flax, almond, rape, &c.

2. Volatile oil is obtained by diftillation from the leaves, flowers, or roots of aromatic plants, as lavender, [illegible].

As an account of the properties of oils has been given already in the article CHEMISTRY, *Suppl.* it would be fuperfluous to repeat it here.

SECT. X. Of Camphor.

The laurus camphora is a tree which grows in China, Japan, and feveral parts of India. When the roots of this tree are put into an [illegible] furnifhed with a capital, and a [illegible] heat [illegible] a particular fubftance fublimes [illegible] known by the name of *camphor*. The Dutch afterwards purify this camphor by a fecond fublimation.

Camphor is a white brittle fubftance, having a peculiar aromatic odour and a ftrong tafte.

47 Properties of camphor. It is not altered by atmofpheric air; but it is fo volatile, that if it be expofed during warm weather in an open veffel, it evaporates completely. When fublimed in clofe veffels it cryftallifes in hexagonal plates or pyramids *.

* Romieu.

It is infoluble in water; but it communicates to that liquid a certain portion of its peculiar odour.

It diffolves readily in alcohol, and is precipitated again by water. If the alcohol be diluted with water as much as poffible, without caufing the camphor to precipitate, fmall cryftals of camphor refembling feathers gradually form †.

† Romieu, Mem. Par. 1756, p. 41.

Camphor is foluble alfo in hot oils, both fixed and volatile; but as the folution cools the camphor precipitates, and affumes the form of plumofe, or feather-like cryftals ‡.

‡ Romieu, Mem. Par. 1756, p. 41.

Camphor is not acted on by alkalies, either pure or in the ftate of carbonats. Pure alkalies indeed feem to diffolve a little camphor; but the quantity is too fmall to be perceptible by any other quality than its odour §. Neither is it acted upon by any of the neutral falts which have hitherto been tried.

§ Bouillon la Grange, Ann. de Chim. xxiii. 154.

Acids diffolve camphor, but it is precipitated again, unaltered, by alkalies, and even by water. The folution of camphor in fulphuric acid is red; that in the nitric acid is yellow. This laft folution has obtained the abfurd name of *oil of camphor*. When nitric acid is diftilled repeatedly off camphor, it converts it into camphoric acid.

Muriatic, fulphurous, and fluoric acids, in the ftate of gas, diffolve camphor. When water is added, the camphor appears unaltered in flakes, which fwim on the furface of the water §.

§ Fourcroy.

When heat is applied to camphor it is volatilized. If the heat be fudden and ftrong, the camphor melts before it evaporates. It catches flame very readily, and emits a great deal of fmoke as it burns, but it leaves no refiduum. It is fo inflammable that it continues to burn even on the furface of water. When camphor is fet on fire in a large glafs globe filled with oxygen gas, and containing a little water, it burns with a very bright flame, and produces a great deal of heat. The inner furface of the glafs is foon covered with a black powder, which has all the properties of charcoal, a quantity of carbonic acid gas is evolved, the water in the globe acquires a ftrong fmell, and is impregnated with carbonic acid and camphoric acid ||.

If two parts of alumina and one of camphor be formed into a pafte with water, and diftilled in a glafs retort, there comes over into the receiver (which fhould contain a little water, and communicate with a pneumatic apparatus) a volatile oil of a golden yellow colour, a little camphoric acid which diffolves in the water, and a quantity of carbonic acid gas, and carbonated hydrogen gas, which may be collected by means of a pneumatic apparatus. There remains in the retort a fubftance of a deep black colour, compofed of alumina and charcoal. By this procefs, from 122.284 parts of camphor, Mr Bouillon la Grange, to whom we are indebted for the whole of the analyfis of camphor, obtained 45.856 parts of volatile oil, and 30.571 parts of charcoal. The proportion of the other products was not afcertained *. 48 Its analyfis.

|| Bouillon la Grange, ibid. p. 168.

* Ibid. p. 157.

From this analyfis, Mr Bouillon la Grange concludes, that camphor is compofed of volatile oil, and charcoal or carbon, combined together. We learn, from his experiments, that the ultimate ingredients of camphor are carbon and hydrogen; and that the proportion of carbon is much greater than in oils.

Camphor exifts in a great many plants. Neumann, Geoffroy, and Cartheufer, extracted it from the roots of zedoary, thyme, fage, &c. and rendered it probable that it is contained in almoft all the labiated plants. It has been fuppofed to exift in thefe plants combined with volatile oil. Prouft has fhewn how it may be extracted, in confiderable quantity, from many volatile oils †. 49 Plants containing it.

† Ann. de Chim. xxxi. 179.

Camphor, which was unknown to the ancient Greeks and Romans, was introduced into Europe by the Arabians.

Reſins.

bans. Æt[illegible] is the firſt perſon who mentions it. It ſeems, however, to have been very early known to the eaſtern nations.

It is much uſed in medicine. It is a powerful ſtimulant; it is conſidered as peculiarly efficacious in diſeaſes of the urinary organs; it is often ſerviceable in [illegible], and procures ſleep when every other medicine fails.

SECT. XI. *Of Resins.*

There is a yellowiſh white coloured ſubſtance which often exſudes from the *Abies Montana*, or *common Scotch fir*, and likewiſe from other fir trees. It is ſomewhat tranſparent, is hard and brittle, of a diſagreeable taſte, and may be collected in conſiderable quantities. This ſubſtance is known by the name of *reſin*; and the ſame name is alſo applied to all ſubſtances which poſſeſs nearly the ſame properties with it. Reſin may be diſtinguiſhed from every other ſubſtance by the following properties:

50 Properties of reſin.

It is more or leſs concrete, and has an acrid and hot taſte.

It is totally inſoluble in water. By this property it may eaſily be ſeparated from gum, if they happen to be mixed together.

It is ſoluble in alcohol, and in ſulphuric ether *. By the firſt of theſe properties we may ſeparate it from gum, and by the laſt from extract; for extract is inſoluble in ſulphuric ether. When theſe ſolutions are evaporated the reſin is obtained unaltered. If the ſolution be ſpread thin upon any body, it ſoon dries by the evaporation of the alcohol; the reſin remains behind, and covers the body with a ſmooth ſhining tranſparent coat, which cannot be waſhed off by water. This proceſs is called *varniſhing*.

* Ib.

Reſin is ſoluble alſo in volatile oils; and theſe ſolutions are often uſed likewiſe in varniſhing.

Reſin is ſcarcely acted upon by acids. Alkalies combine with it, but the combination is not eaſily effected.

When reſin is heated it readily melts; and if the heat be increaſed it is volatilized, and burns with a white flame and ſtrong ſmell. When diſtilled it yields much volatile oil, but ſcarcely any acid.

When volatile oils are expoſed for ſome time to the action of the atmoſphere they acquire conſiſtency, and aſſume the properties of reſins. During this change they abſorb a quantity of oxygen from the air. Weſtrum put 30 grains of oil of turpentine into 40 cubic inches of oxy-muriatic acid gas. Heat was evolved, the oil gradually evaporated, and aſſumed the form of yellow reſin †. Theſe facts render it probable that reſin is merely volatile oil combined with a quantity of oxygen.

† Crell Annals 1790.

To know whether any vegetable ſubſtance contains reſin, we have only to pour ſome ſulphuric ether upon it in powder, and expoſe the infuſion to the light. If any reſin be preſent the ether will aſſume a brown colour ‡.

‡ Hermſtadt.

51 Number of reſins.

The number of reſins is conſiderable. They differ from each other chiefly in colour, taſte, ſmell, and conſiſtency. Whether theſe reſins be really different combinations, or, as is moſt likely, owe theſe differences to foreign ingredients, either combined with the reſin, or mechanically mixed with it, is not at preſent known. To deſcribe each reſin ſeparately would be to little purpoſe, as ſcarcely any thing is known of them except their general properties as reſins. The following is a liſt of the principal. The reader will find an account of the manner of obtaining them, and of their uſes, by conſulting the name of each in the *Encyclopædia*.

1. Common reſin,	7. Sandarac,
2. Turpentine,	8. Guaiacum,
3. Pitch,	9. Labdanum,
4. Galipot,	10. Dragon's blood,
5. Elemi,	11. Copaiba.
6. Maſtic,	

52 Balſams.

There are three vegetable ſubſtances which have been denominated *balſams* by ſome of the later French writers. They appear to conſiſt of reſin, or volatile oil combined with benzoic acid. Theſe ſubſtances are, benzoin, balſam of Tolu, and ſtorax. For an account of them we refer to the *Encyclopædia*.

53 Gum reſins.

Many vegetable ſubſtances occur in medicine which conſiſt chiefly of a mixture of gum and reſin. Theſe ſubſtances, of courſe, have a number of the properties both of gums and reſins. For this reaſon they have been denominated *gum reſins*. The following are the moſt important of theſe ſubſtances:

Olibanum,	Aloes,
Galbanum,	Myrrh,
Scammony,	Ammoniac,
Aſafœtida,	Opium.

For an account of them we refer to the *Encyclopædia*.

SECT. XII. *Of Caoutchouc.*

54 Diſcovery of caoutchouc.

About the beginning of the 18th century a ſubſtance, called *caoutchouc*, was brought as a curioſity from America. It was ſoft, wonderfully elaſtic, and very combuſtible. The pieces of it that came to Europe were uſually in the ſhape of bottles, birds, &c. This ſubſtance is very much uſed in rubbing out the marks made upon paper by a black lead pencil; and therefore in this country it is often called *Indian rubber*. Nothing was known of its production, except that it was obtained from a tree, till the French academicians went to South America in 1735 to meaſure a degree of the meridian. Mr de la Condamine ſent an account of it to the French Academy in the year 1736. He told them, that there grew in the province of Eſmeraldas, in Braſil, a tree, called by the natives *Hhevé*; that from this tree there flowed a milky juice, which, when inſpiſſated, was *caoutchouc*. Don Pedro Maldonado, who accompanied the French academicians, found the ſame tree on the banks of the Maragnon; but he died ſoon after, and his papers were never publiſhed. Mr Freſnau, after a very laborious ſearch, diſcovered the ſame tree in Cayenne. His account of it was read to the French Academy in 1751.

55 Plants containing it.

It is now known that there are at leaſt two trees in South America from which caoutchouc may be obtained, the Hævea Caoutchouc and the Jatropha Elaſtica; and it is exceedingly probable that it is extracted alſo from other ſpecies of Hævea and Jatropha. Several trees likewiſe which grow in the Eaſt Indies yield caoutchouc; the principal of theſe are, the Ficus Indica, the Artocarpus Integrifolia, and the Urceola Elaſtica; a plant diſcovered by Mr Howiſon, and firſt deſcribed and named by Dr Roxburgh *.

* Aſiatic Reſearches, v. 167. London edition.

Caoutchouc When any of these plants is punctured, there exsudes from it a milky juice, which, when exposed to the air, gradually lets fall a concrete substance, which is caoutchouc.

If oxy-muriatic acid be poured into the milky juice, the caoutchouc precipitates immediately, and, at the same time, the acid loses its peculiar odour. This renders it probable that the formation of the caoutchouc is owing to its basis absorbing oxygen *. If the milky juice be confined in a glass vessel containing common air, it gradually absorbs oxygen, and a pellicle of caoutchouc appears on its surface †.

* Fourcroy, Ann. de Chim. xi. 219.
† Ibid.

56 Properties of caoutchouc. Caoutchouc was no sooner known than it drew the attention of philosophers. Its singular properties promised that it would be exceedingly useful in the arts, provided any method could be fallen upon to mould it into the various instruments for which it seemed peculiarly adapted. Messrs de la Condimine and Fresnau had mentioned some of its properties; but Macquer was the first person who undertook to examine it with attention. His experiments were published in the memoirs of the French Academy for the year 1768. They threw a good deal of light on the subject; but Macquer fell into some mistakes, which were pointed out by Mr Berniard, who published an admirable paper on caoutchouc in the 17th volume of the *Journal de Physique*. To this paper we are indebted for the greater number of facts at present known respecting caoutchouc. Mr Groffart and Mr Fourcroy have likewise added considerably to our knowledge of this singular substance; both of their treatises have been published in the 11th volume of the *Annales de Chimie*.

Caoutchouc, when pure, is of a white colour (c), and without either taste or smell ‡. The blackish colour of the caoutchouc of commerce is owing to the method [illegible] it after it has been spread upon moulds. The usual way is to spread a thin coat of the milky juice upon the mould, and then to dry it by exposing it to smoke; afterwards another coat is spread on, which is dried in the same way. Thus the caoutchouc of commerce consists of numerous layers of pure caoutchouc alternating with as many layers of soot.

‡ Fourcroy, ibid. 232.

Caoutchouc is soft and pliable like leather. It is exceedingly elastic and adhesive; so that it may be forcibly stretched out much beyond its usual length, and instantly recover its former bulk when the force is withdrawn. It cannot be broken without very considerable force.

57 Action of water, It is not altered by exposure to the air; it is perfectly insoluble in water; but if boiled for some time its edges become somewhat transparent, owing undoubtedly to the water carrying off the soot; and so soft, that when two of them are pressed and kept together for some time, they adhere as closely as if they formed one piece. By this contrivance pieces of caoutchouc may be soldered together, and thus made to assume whatever shape we please §.

§ Groffart, Ann. de Chim. xi. 153.

58 Alcohol, Caoutchouc is insoluble in alcohol. This property was discovered very early, and fully confirmed by the experiments of Mr Macquer. The alcohol, however, renders it colourless.

59 Ether, Caoutchouc is soluble in ether. This property was first pointed out by Macquer. Berniard, on the contrary, found that caoutchouc was scarcely soluble at all in sulphuric ether, which was the ether used by Macquer, and that even nitric ether was but an imperfect solvent. The difference in the results of these two chemists was very singular; both were remarkable for their accuracy, and both were too well acquainted with the subject to be easily misled. The matter was first cleared up by Mr Cavallo. He found that ether, when newly prepared, seldom or never dissolved caoutchouc completely; but if the precaution was taken to wash the ether previously in water, it afterwards dissolved caoutchouc with facility. Mr Groffart tried this experiment, and found it accurate ||. It is evident from this that these chemists had employed ether in different states. The washing of ether has two effects. It deprives it of a little acid with which it is often impregnated, and it adds to it about one-tenth of water, which remains combined with it.

|| Ann. de Chim. xi. 147.

When the ether is evaporated, the caoutchouc is obtained unaltered. Caoutchouc, therefore, dissolved in ether, may be employed to make instruments of different kinds, just as the milky juice of the hævea; but this method would be a great deal too expensive for common use.

60 Oils, Caoutchouc is soluble in volatile oils *; but, in general, when these oils are evaporated, it remains somewhat glutinous, and therefore is scarcely proper for those uses to which, before its solution, it was so admirably adapted.

* Berniard.

61 Acids and alkalies, It is insoluble in alkalies †. The acids act upon it with more or less violence according to their nature. Sulphuric acid decomposes it completely, charcoal precipitates, and part of the acid is converted into sulphurous acid. Nitric acid converts it into a yellow substance, analogous to suberic acid. Muriatic acid does not affect it ‡. The other acids have not been tried.

† Id.
‡ Id.

Fabroni has discovered, that rectified petroleum dissolves it, and leaves it unaltered when evaporated ¶.

¶ Ibid. 195. and xii. 156.

62 Heat. When exposed to heat it readily melts; but it never afterwards recovers its properties, but continues always of the consistence of tar. It burns very readily with a bright white flame, and diffuses a fetid odour. In those countries where it is produced, it is often used by way of candle.

When distilled, it gives out ammonia §. It is evident from this, and from the effect of sulphuric and nitric acid upon it, that it is composed of carbon, hydrogen, azot, and oxygen; but the manner in which they are combined is unknown.

§ Fourcroy, Ann. de Chim. xi. 232.

When treated with nitric acid, there came over azotic gas, carbonic acid gas, prussic acid gas; and oxalic acid was formed ||.

|| Ibid.

63 How to separate it from plants. It seems to exist in a great variety of plants; but is usually confounded with the other ingredients. It may be separated from resins by means of alcohol. It may be extracted from the different species of *misseltoe* by water, with which, in the fluid state in which it exists in these plants, it readily combines. When mixed with gum or extract, it may be separated by the following process: Digest a part of the plant containing it first in water and then in alcohol, till all the substances soluble

(c) Mr De Fourcroy says, that blackish brown is the natural colour of caoutchouc. But we have seen some pieces of it from the East Indies, which had been allowed to inspissate in the open air: They were white, with a slight cast of yellow, and had very much the appearance and feel of white soap.

Wax

luble in these liquids be extracted. Dry the residuum, and digest it in five times its weight of rectified petroleum. Express the liquid part by squeezing the substance in a linen cloth. Let this liquid remain several days to settle, then decant off the clear liquid part, mix it with a third part of water and distil, the caoutchouc remains behind *.

* Hermstadt, Med. Phys. Jo iii. 372.

SECT. XIII. *Of Wax.*

THE upper surface of the leaves of many trees is covered with a varnish of wax. This varnish may be separated and obtained in a state of purity by the following process.

64
Wax a vegetable production.

Digest the bruised leaves, first in water and then in alcohol, till every part of them which is soluble in these liquids be extracted. Then mix the residuum with six times its weight of a solution of pure ammonia, and, after sufficient maceration, decant off the solution, filter it, and drop into it, while it is incessantly stirred, diluted sulphuric acid, till more be added than is sufficient to saturate the alkali. The wax precipitates in the form of a yellow powder. It should be carefully washed with water, and then melted over a gentle fire †.

† Ib. ibid. 373.

Mr Tingry first discovered that this varnish possessed all the properties of *bees wax* ‡. Wax then is a vegetable product. The bees extract it unaltered from the leaves of trees and other vegetable substances which contain it. They seem, however, to mix it with some of the pollen of flowers.

‡ Enc. Meth. Forets et Bois, i. 100.

65
Its properties.

Wax, when pure, is of a whitish colour, it is destitute of taste, and has scarcely any smell. Bees wax indeed has a pretty strong aromatic smell; but this seems chiefly owing to some substance with which it is mixed; for it disappears almost completely by exposing the wax, drawn out into thin ribands, for some time to the atmosphere. By this process also, which is called *bleaching*, the yellow colour of the wax disappears, and it becomes very white. Bleached wax is not affected by the air §.

§ Senebier, Ann. de Chim, xii. 60 and Jour. de Phys. xxxviii. 56.

Wax is insoluble in water and in alcohol. It combines readily with alkalies, and forms with them a soap which is soluble in water ‖.

‖ Chaptal, iii 164.

Punic wax, which the ancients employed in painting in encausto, is a soap composed of twenty parts of wax and one of soda *. Its composition was ascertained by Mr Lorgna †.

* Plin l. 21. c. 14.
† Jour. de Phys. Nov. 1785.

Sulphuric and nitric acids decompose wax completely; oxy-muriatic acid bleaches it instantaneously.

Wax combines readily with oils, and forms with them a substance of greater or less consistency according to the quantity of oil. This composition, which is known by the name of *cerate*, is much employed by surgeons.

When heat is applied to wax it becomes soft; and at the temperature of 142°, if unbleached, or of 155° if bleached ‡, it melts into a colourless transparent fluid, which concretes again, and resumes its former appearance as the temperature diminishes. If the heat be still farther increased, the wax boils and evaporates; and if a red heat be applied to the vapour, it takes fire and burns with a bright flame. It is this property which renders wax so useful for making candles.

‡ Nicholson's Journal, i. 71.

66
Analysis.

Mr Lavoisier, by means of the apparatus described in the article CHEMISTRY, *Suppl.* n° 353. contrived to burn wax in oxygen gas. The quantity of wax consumed was 21.9 grains. The oxygen gas employed in consuming that quantity amounted to 66.55 grains. Consequently the substances consumed amounted to 88.45 grains. After the combustion, there were found in the glass vessel 62.58 grains of carbonic acid, and a quantity of water, which was supposed to amount to 25.87 grains. These were the only products.

Woody Fibre.

Now 62.58 grains of carbonic acid gas contain

44.50 of oxy and 18.02 of carb; and 25.87 gr of water contain
21.99 of oxy and 3.88 of hydro.

66.55	21.9?

Consequently 21.9 parts of wax are composed of 18.02 of carbon, and 3.88 of hydrogen. And 100 parts of wax are composed of

82.28 carbon,
17.72 hydrogen,

100.00 *.

* Lavoisier, Jour de Phys. xxxi. 59.

If wax be distilled with a heat greater than 212°, there comes over a little water, some sebacic acid, a little very fluid and odorous oil: the oil, as the distillation advances, becomes thicker and thicker, till at last it is of the consistency of butter, and for this reason has been called *butter of wax*. There remains in the retort a small quantity of coal, which is not easily reduced to ashes. When the butter of wax is repeatedly distilled it becomes very fluid, and assumes the properties of volatile oil †.

† Lemery, Mem. Par. 1708, p. 33.

SECT. XIV. *Of the Woody Fibre.*

ALL trees, and most other plants, contain a particular substance, well known by the name of *wood*. If a piece of wood be well dried, and digested, first in a sufficient quantity of water, and then of alcohol, to extract from it all the substances soluble in these liquids, there remains behind only the *woody fibre*.

67
Properties of wood.

This substance, which constitutes the basis of wood, is composed of longitudinal fibres, easily subdivided into a number of smaller fibres. It is somewhat transparent; is perfectly tasteless; has no smell; and is not altered by exposure to the atmosphere.

It is insoluble in water and in alcohol; but soluble in alkalies. The mineral acids decompose it. When distilled it yields, in all probability, pyrolignous acid. When burnt with a smothered fire it leaves behind it a considerable quantity of charcoal.

It is precipitated from alkalies unaltered by acids *.

* Fourcroy, Ann. de Chim. viii. 149.

68
Its analysis.

By nitric acid Fourcroy converted the residuum of quinquina, which does not seem to differ from the woody fibre, into oxalic acid; at the same time there was a little citric acid formed, and a very small quantity of malic and acetous acids. Some azotic gas also was disengaged. By this process he obtained from 100 parts of woody fibre

56.250	oxalic acid,
3.905	citric acid,
0.388	malic acid,
0.486	acetous acid,
0.867	azotic gas,
8.330	carbonat of lime,
70.226	
32.031	residuum.
102.257	

There was likewise a quantity of carbonic acid gas disengaged, the weight of which was unknown. This

increase

Acids.

increase of weight in the product was evidently owing to the oxygen derived from the nitric acid *.

* Ann. de Chim. viii. 152.

When distilled in a retort, 100 parts yield the following products:

26.62	of a yellow liquid, containing alcohol, and acid which had the smell of pyromucous.
6.977	of concrete oil, mostly soluble in alcohol.
22.995	charcoal } in the retort.
3.567	carbonat of lime } in the retort.
60.159	
39.841	gas, half carbonic acid, half carbonated hydrogen.
100.000 *	

* Ibid. 151.

These facts shew us, that the woody fibre is composed of oxygen, carbon, hydrogen, azot, and lime. Mr Chaptal supposes that mucilage differs from woody fibre merely in containing less oxygen. We are certain at least that mucilage or gum is composed of the same ingredients; and Mr Chaptal has shewn, that the juices of plants are partly converted into woody fibre by oxy-muriatic acid, which imparts to them oxygen †. These juices contain both gum and resin; after the formation of the woody fibre the resin is still unaltered. This gives a good deal of probability to his opinion.

† Ibid. xxi. 285.

SECT. XV. *Of Acids.*

THE acids found ready formed in vegetables are the following:

1. Oxalic,	5. Gallic,
2. Tartarous,	6. Benzoic,
3. Citric,	7. Phosphoric.
4. Malic,	

Sometimes also the sulphuric, nitric, and muriatic [illegible] vegetables, combined with alkalies or [illegible] except in very minute quantities.

69 Plants containing [illegible] acid,

1. [illegible] easily detected and distinguished by [illegible] It decomposes all calcareous [illegible] with lime a salt [illegible] water. It [illegible] prisms. It [illegible] by heat.

Oxalic acid [illegible] in vegetables by Mr Scheele. It has [illegible] plants:

The leaves of [illegible]

[illegible]

The root of [illegible]

The leaves of the geranium [illegible]

* Scheele, Crell's Jour. [illegible]. 107. Eng. Transl.
† Ibid. 34.
‡ Hermstadt.

70 Tartarous acid,

2. Tartarous acid is known by the following properties: When a little potass is cautiously dropt into a solution containing it, common tartar is formed, and precipitates to the bottom. Tartarous acid does not decompose the sulphat, nitrat, or muriat of lime. Tartrite of lime is soluble in water. Tartarous acid crystallizes. Its crystals are long slender prisms. It is destroyed by heat.

Tartarous acid has been found in the following vegetable substances:

The pulp of the tamarind *.
The juice of grapes.
 Mulberries †.
 Rumex acetosa, *sorrel* †.
 Rhus coriaria, *sumach* †.
 Rheum rhaponticum ‖.
 Agave Americana ¶.
The roots of triticum repens †.
 Leontodon taraxicum †.

* Vauquelin, Ann. de Chim. v. 92.
† Hermstadt on Veget. Acids.
‖ Bindheim, Crell, 1788, St. 7. s. 42.
¶ Hoffman of Weimar.
† Hermstadt on Veget. Acids.

71 Citric acid,

3. Citric acid is distinguished by the following properties: It does not form tartar when potass is added to it. With lime it forms a salt insoluble in water, which is decomposed by sulphuric, nitric, and muriatic acids. It readily crystallizes. It is destroyed by heat.

Citric acid has been found unmixed with other acids in the following vegetable substances *:

The juice of oranges and lemons.
The berries of vaccinium oxycoccos, *cranberry*.
 ——— vitis idæa, *red whortle berry*.
 Prunus padus, *birdcherry*.
 Solanum dulcamara, *nightshade*.
 Rosa canina, *hip*.

* Scheele, Crell's Jour. ii. 8. Eng. Transl.

It occurs mixed with other acids in many other fruits.

72 Malic acid,

4. Malic acid is known by the following properties: It forms with lime a salt soluble in water, which is decomposed by citric acid. It does not form tartar with potass. It is incrystallizable. Heat destroys it.

Malic acid has been found, by Scheele †, in the fruits of the following plants, which contain no other acid:

Apples.
Berberis vulgaris, *barberry*.
Prunus domestica, *plum*.
——— spinosa, *sloe*.
Sambucus nigra, *elder*.
Sorbus aucuparia, *roan* or *service*.

† Ibid.

73 Malic and citric,

In the following fruits he found nearly an equal quantity of malic and citric acids ‡.

Ribes grossularia, *gooseberry*.
——— rubrum, *currants*.
Vaccinium myrtillus, *bleaberry*.
Crategus aria, *beam*.
Prunus cerasus, *cherry*.
Fragaria vesca, *strawberry*.
Rubus chamæmorus, *cloudberries*, *evrocks*.
——— idæus, *raspberry*.

‡ Ibid.

Malic acid has also been found in the agave americana §, and in the pulp of tamarinds ‖. In the first of these it is mixed with tartarous acid; in the second with tartarous and citric acids.

§ Hoffman of Weimar.
‖ Vauquelin, Ann. de Chim. v. 92.

74 Gallic acid,

5. Gallic acid is known by the following properties: With the brown oxyd of iron it produces a black colour. It is crystallizable. Heat destroys it. It has been found in a great number of plants, chiefly in the bark.—The following table, drawn up by Mr Biggin *, will serve to shew the relative proportions of this acid in different plants:

Elm	7	Sallow	8
Oak cut in winter	8	Mountain ash	8
Horse chesnut	6	Poplar	8
Beech	7	Hazel	9
Willow (boughs)	8	Ash	10
Elder	4	Spanish chesnut	10
Plum tree	8	Smooth oak	10
Willow (trunk)	9	Oak cut in spring	10
Sycamore	6	Huntingdon or Leicester willow	10
Birch	4		
Cherry tree	8	Sumach	14

* Nicholson's Journal, iii. 394.

75 Benzoic acid,

6. Benzoic acid is distinguished by its aromatic odour, and its volatility on the application of a very moderate heat. It has been found hitherto only in three vegetable substances, to which the French chemists have confined the term *balsam*. These three are, *benzoin*, *balsam of tolu*, and *storax*. In these substances it seems to be combined with a resin, or something which has nearly the properties of a resin.

 7. Phos-

7. Phosphoric acid is easily distinguished from the former six, for it is very fixed, and a violent heat does not destroy it as it does the others.

Phosphoric acid has been found in different plants, but only in very small quantities; it is almost constantly combined with lime. Meyer found it in the leaves of many trees*; Thuren found phosphat of lime in the Aconitus Napellus †; and Bergmann found it in all kinds of grain ‡.

* Enc. Meth. Physiol. Veget. i. 100.
† Ann. de Chim. ii. 308.
‡ Bergman, v. 96.

SECT. XVI. *Of ALKALIES.*

THE only alkalies found in plants are potass and soda. Ammonia may indeed be obtained by distilling many vegetable substances, but it is produced during the operation. One or other of these alkalies is found in every plant which has hitherto been examined. The quantity indeed is usually very small.

77 Proportion of potass in plants.
1. Potass is found in almost all plants which grow at a distance from the sea. It may be extracted by burning the vegetable, washing the ashes in water, filtrating the water, and evaporating it to dryness. It is in this manner that all the potash of commerce is procured.

The following table exhibits the quantity of ashes and potass which may be extracted from 100 parts of various plants:

	Ashes.	*Potass.*
Sallow	2.8	0.285*(c)
Elm	2.36727	0.39*
Oak	1.35185	0.15343
Poplar	1.23476	0.07481
Hornbeam	1.1283	0.1254
Beech	0.58432	0.14572
Fir	0.34133	
Vine branches	3.379	0.55*
Common nettle	10.67186	2.5033
Common thistle	4.04265	0.53734
Fern	5.00781	0.6259
Cow thistle	10.5	1.96603
Great river rush	3.85395	0.72234
Feathered rush	4.33593	0.50811
Stalks of turkey wheat	8.86	1.75*
Wormwood	9.744	7.3*
Fumitory	21.9	7.9*
Trifolium pratense		0.078*
Vetches		2.75*
Beans with their stalks		2.0*

In general, three times as much ashes are obtained from shrubs, and five times as much from herbs, as from trees. Equal weights of the branches of trees produce more ashes than the trunk, and the leaves more than the branches. Herbs arrived at maturity produce more ashes than at any other time. Green vegetables produce more ashes than dry †.

† Ann. de Chim. xx. 174.

The salt which is obtained from plants does not consist wholly of potass, there are other salts mixed with it; these usually are sulphat of potass, muriat of potass, sulphat of lime, phosphat of lime, &c.; but these bear, in general, but a small proportion to the potass. The ashes consist of potass mixed with earths.

Some judgment may be formed of the quantity of potass which a plant contains from the quantity of ashes which it yields: but the above table is sufficient to shew us, that were we to trust to that we would often be misled.

2. Soda is found in almost all the plants which grow in the sea, and in many of those which grow on the shore. In general, the quantity of soda which plants contain bears a much greater proportion to their weight than the potass does which is found in inland vegetables. 100 parts of the *salsola soda*, for instance, yield 19.921 of ashes; and these contain 1.992 parts of soda, some of which, however, is combined with muriatic acid *. The plants from which the greater part of the soda, or *barilha*, as it is called, which is imported from Spain, is extracted, are the *salsola sativa*, and *vermiculata*.

* Vauquelin, Ann. de Chim. xviii. 77.

SECT. XVII. *Of EARTHS.*

THE only earths hitherto found in plants are the four following; *lime, silica, magnesia, alumina.*

79 Lime.
1. Lime is usually the most abundant of the earths of plants, and the most generally diffused over the vegetable kingdom. Indeed, it is a very uncommon thing to find a plant entirely destitute of lime: salsola soda is almost the only one in which we know for certain that this earth does not exist *.

* Id. ibid.

80 Silica.
2. Silica exists also in many plants, particularly grasses and equisetums. Mr Davy has ascertained, that it forms a part of the epidermis, or outermost bark of these plants; and that in some of them almost the whole epidermis is silica.

		Parts Silica.
100 parts of the epid. of	bonnet-cane yielded	90
	bamboo	71.4
(arundo phragm.)	common reed	48.1
	stalks of corn	6.5

The concretions which are sometimes found in the bamboo cane have been ascertained by Mr Macie to be composed of pure silica.

81 Magnesia.
3. Magnesia does not exist so generally in the vegetable kingdom as the two preceding earths. It has been found, however, in considerable quantities in several sea plants, especially fuci †. But the salsola soda contains a greater proportion of magnesia than any plant hitherto examined. Mr Vauquelin found that 100 parts of it contained 17.929 of that earth ‡.

† Id. ibid. 90. and ix. 94.
‡ Ibid. 78.

82 Alumina.
4. Alumina has only been found in very small quantities in plants.

83 Proportion of earth in plants.
The following table will shew the quantity of these four earths which exist in several vegetables.

100 parts of	oak contain of earths	1.03*
	Beech	0.453†
	Fir	0.003†
	Turkey wheat	7.11†
	Sunflower	3.72†
	Vine branches	2.85†
	Box	2.674†
	Willow	2.515†
	Elm	1.96†
	Aspin	1.146†
	Fern	3.221‡
	Wormwood	2.444§
	Fumitory	14.000§

* Watson.
† Kirwan, Irish Trans. iii. 35.
‡ Home.
§ Wiegleb.

This

(c) Those marked * are from *Kirwan, Irish Trans.* v. 164. The rest from *Pertuis, Ann. de Chim.* 19. 178.

Metals. Vegetation.

This table shews us, that the quantity of earth is greater in herbs than in trees.

Bergman found all the four earths in every kind of grain which he analysed *.

Vaquelin found, that 100 parts of oat grain left 3.1591 of residuum. This residuum is composed of

60 7 silica,
39 3 phosphat.

100.0 †.

When the whole of the avena sativa, however, stalk and seed together, are burnt, they leave a residuum composed of

55 silica,
15 phosphat of lime,
20 potass,
5 carbonat of lime.

95, and a little oxyd of iron ‡.

This shews us that the stalk contains several substances not to be found in the grain.

* Opusc. v. 94.
† Ann de Chim. xxix. 17.
‡ Ibid. 19.

Sect. XVIII. Of Metals.

Several metallic substances have also been found in vegetables, but their quantity is exceedingly small; so small, indeed, that without very delicate experiments their presence cannot even be detected.

84 Three metals found in plants.

The metals hitherto discovered are iron, which is by far the most common, manganese, and gold.

Scheele first detected manganese in vegetables *. Proust found it in the ashes of the pine, calendula, vine, green oak, and fig-tree †. M. Sage has shewn, that gold exists in many plants. Iron exists in most plants. The ashes of some species of salsola contain a considerable quantity of it.

* Opusc. i. 06.
† Phil. Mag. v. 9.

We have now taken a survey of all the substances which have hitherto been obtained from vegetables: by [illegible] of these, we come at last to those bodies which we are at present obliged to consider as simple, because they have not yet been decomposed, and of which accordingly we must suppose that vegetables are ultimately composed. These bodies amount to 16, namely,

85 Simple substances contained in plants.

1. Oxygen,	9. Gold,
2. Sulphur,	10. Lime,
3. Phosphorus,	11. Magnesia,
4. Carbon,	12. Silica,
5. Hydrogen,	13. Alumina,
6. Azot,	14. Potass,
7. Iron,	15. Soda,
8. Manganese,	16. Muriatic acid.

But of these substances there are twelve which compose but a very small proportion indeed of vegetables. Almost the whole of vegetable substances are composed of four ingredients, namely,

Carbon, Oxygen,
Hydrogen, Azot.

Of these the last, namely azot, forms but a small proportion even of those vegetable substances of which it is a constituent part, while into many it does not enter at all: So that, upon the whole, by far the greater part of vegetable substances is composed of carbon, hydrogen, and oxygen. We do not mention caloric and light, concerning the nature of which too little is known to enable us to determine with certainty into what substances they enter.

The substances at present known to chemists, which they have not been hitherto able to decompose, amount (omitting caloric and light) to 40. Sixteen of these exist in plants; the other 24 belong exclusively to the mineral kingdom: for it is a fact, that no substance (we mean simple substance) has been hitherto found in the animal kingdom which does not exist also in vegetables.

On the contrary, all the simple substances at present known may be found in minerals. This indeed ought not to surprise us, if we recollect, that the spoils of animals and vegetables, after they have undergone decomposition, are ultimately confounded with minerals, and consequently arranged under the mineral kingdom. Besides, as vegetables draw all their food from the mineral kingdom, it would be absurd to suppose that they contain substances which they could not have procured from minerals. It must follow, therefore, of necessity, that minerals contain all the simple substances which exist in this globe of our's; and that plants owe their diversity merely to different modifications of those principles which they imbibe from the soil. But it is impossible to have any precise notions about a subject so intricate, without considering with some attention the structure of vegetables, the food which they imbibe, and the changes which they produce on that food. These enquiries shall form the subject of the next chapter; in which we propose to take a view of those phenomena of vegetation which are connected with chemistry, or which may be elucidated by the application of the principles of that science.

Chap. II. Of Vegetation.

We have now seen the different substances which are contained in plants; but we have still to examine the manner in which these substances are produced, and to endeavour to trace the different processes which constitute vegetation. We must warn our readers not to expect complete information in this chapter. The wonders of the vegetable kingdom are still but very imperfectly explored; many of the organs of plants are too minute for our senses; and scarcely a single process can be completely traced.

86 Phenomena of vegetation very numerous.

The multiplicity of operations continually going on in vegetables at the same time, and the variety of different, and even opposite substances, formed out of the same ingredients, and almost in the same place, astonish and confound us. The order, too, and the skill with which every thing is conducted, are no less surprising. No two operations clash; there is no discord, no irregularity, no disturbance; every object is gained, and every thing is ready for its intended purpose. This is too wonderful to escape our observation, and of too much importance not to claim our attention. Many philosophers, accordingly, distinguished equally by their industry and sagacity, have dedicated a great part of their lives to the study of *vegetation*. But hitherto their success has not been equal to their exertions. No person has been able to detect this *agent*, always so busy, and performing such wonders, or to discover him at his work; nor have philosophers been much more fortunate

Vegeta-nate in their attempts to ascertain the instruments which he employs in his operations. A great variety, however, of curious and interesting facts, have been discovered. These we shall attempt in this chapter to collect and arrange, to point out their dependence on each other, and perhaps to deduce such consequences as obviously result from this mutual dependence.

87 Plant from seed.

1. Natural historians have proved, by a very complete induction of facts, that all plants arise from *seeds*. The pretended exceptions have disappeared, one after another, as our knowledge of vegetables increased: and now there remains scarcely a single objection entitled to the smallest regard. The late attempt of Girtanner * to revive the doctrine of equivocal generation, deserves no attention whatever; because his conclusions are absolutely incompatible with the *experiments* of Mr Senebier upon the very substance on which his theory is founded.

* *Ann. de Chim.* xxxiv 35.

88 Seeds composed of three parts.

A SEED consists of three parts; namely, the *cotyledons*, the *radicle*, and the *plumula*, which are usually inclosed in a cover.

If we take a garden bean, we may perceive each of these three parts with great ease; for this seed is of so large a size, that all its organs are exceedingly distinct.

When we strip off the external coats of the bean, which are two, and of different degrees of thickness in different parts, we find that it easily divides into two lobes, pretty nearly of the same size and figure. Each of these lobes is called a *cotyledon* (fig. 1. *a*). The cotyledons of the bean, then, are two in number.

Plate XLIII.

Near that part of the lobes which is contiguous to what is called the *eye* of the bean, there is a small round white body (*b*), which comes out between the two lobes. This body is called the *radicle*.

Attached to the radicle, there is another small round body (*c*), which lies between the cotyledons and wholly within them, so that it cannot be seen till they are separated from each other. This body is called the *plumula*.

The appearance and shape of these three parts differ very much in different seeds, but there is no seed which wants them. The figure and size of the seed depend chiefly upon the cotyledons. This is evidently the case with the bean, and it is so with all other seeds. The number of cotyledons is different in different seeds. Some seeds have only one cotyledon, as the seeds of wheat, oats, barley, and the whole tribe of grasses: some have three; others six, as the seeds of the garden grass; but most seeds, like the bean, have two cotyledons.

89 Germination of seeds

2. When a seed is placed in a situation favourable to vegetation, it very soon changes its appearance. The radicle is converted into a root, and sinks into the earth; the plumula, on the other hand, rises above the earth, and becomes the trunk or stem. When these changes take place, the seed is said to *germinate*: the process itself has been called *germination*. Seeds do not germinate equally and indifferently in all places and seasons. Germination, therefore, is a process which does not depend upon the seed alone, something external must also affect it.

90 Requires moisture,

3. It is a well known fact, that seeds will not germinate unless *moisture* have access to them; for seeds, if they are kept perfectly dry, never vegetate at all, and yet their power of vegetating is not destroyed. There are indeed some apparent objections to this: potatoes, for instance, and other bulbous bodies, germinate, tho' kept ever so dry. But the reason of this is, that these bodies (which are not seeds, though they resemble them in some particulars) have a sufficient quantity of water within themselves to give a beginning to germination. We may conclude, then, that no seed will germinate unless water has access to it. *Water*, then, is essential to germination. Too much water, however, is no less prejudicial to most seeds than none at all. The seeds of water plants, indeed, germinate and vegetate extremely well in water; but most other seeds, if they are kept in water beyond a certain time, are rotted and destroyed altogether.

91 Heat,

4. It is well known also, that seeds will not germinate, even though supplied with water, provided the temperature be below a certain degree. No seed, for instance, on which the experiment has been tried, can be made to vegetate at or below the freezing point: yet this degree of cold does not injure the vegetating power of seeds; for many seeds will vegetate as well as ever after having been frozen, or after having been kept in frozen water. We may conclude, then, that a certain degree of heat is necessary for the germination of seeds. And every species of plants seems to have a degree peculiar to itself, at which its seeds begin to germinate; for we find that almost every seed has a peculiar season at which it begins to germinate, and this season varies always according to the temperature of the air. Mr Adanson found that seeds, when sown at the same time in France and in Senegal, always appeared sooner above ground in the latter country, where the climate is hotter, than in France §.

§ *Sen. Mém. Physiol. Veget.* 124.

92 And oxygen gas.

5. Seeds, although supplied with moisture, and placed in a proper temperature, will not germinate, provided atmospherical air be completely excluded from them. Mr Ray found that grains of lettuce did not germinate in the vacuum of an air-pump, but they began to grow as soon as air was admitted to them ‡. Homberg made a number of experiments on the same subject, which were published in the Memoirs of the French Academy for the year 1693. He found, that the greater number of seeds which he tried refused to vegetate in the vacuum of an air-pump. Some, however, did germinate. But Boyle, Muschenbroek, and Boerhaave, who made experiments on the same subject in succession, proved beyond a doubt that no plant vegetates in the vacuum of an air-pump; and that in those cases in which Homberg's seeds germinated, the vacuum was far from perfect, a quantity of air still remaining in the receiver. It follows, therefore, that no seed will germinate unless atmospherical air, or some air having the same properties, have access to it. It is for this reason that seeds will not germinate at a certain depth below the surface of the earth.

‡ *Phil. Trans.* No 55.

Mr Scheele found that beans would not germinate except oxygen gas were present; Mr Achard afterwards proved, that oxygen gas is absolutely necessary for the germination of all seeds, and that no seed will germinate in azotic gas, or hydrogen gas, or carbonic acid gas, unless these gases contain a mixture of oxygen gas. These experiments have been confirmed by Mr

Vegetation.

Mr Gough, Mr Cruickfhank, and many other philofophers. It follows, therefore, that it is not the whole atmofpheric air, but merely the oxygen gas which it contains, that is neceffary for the germination of feeds.

93 [Injured by the prefence of light.]

6. Seeds do not germinate equally well when they are expofed to the light, and when they are kept in a dark place; light therefore has fome effect on germination.

Mr Ingenhoufz found, that feeds always germinate fafter in the dark than when expofed to the light *. His experiments were repeated by Mr Senebier with equal fuccefs †; and it was concluded, in confequence of their experiments, that light is injurious to germination. But the Abbé Bertholin, who diftinguifhed himfelf fo much by his labours to demonftrate the effect of electricity on vegetation, objected to the conclufions of thefe philofophers, and affirmed, that the difference in the germination of feeds in the fhade and in the light was owing, not to the light itfelf, but to the difference of the moifture in the two fituations; the moifture evaporating much fafter from the feeds in the light than from thofe in the fhade; and he affirmed, that when precautions were taken to keep the feeds equally moift, thofe in the fun germinated fooner than thofe in the fhade ‡. But when Mr Senebier repeated his former experiments, and employed every poffible precaution to enfure the equality of moifture in both fituations, he conftantly found the feeds in the fhade germinate fooner than thofe in the light §. We may conclude, therefore, that light is injurious to germination; and hence one reafon for covering feeds with the foil in which they are to grow.

7. Thus we have feen that feeds will not germinate unlefs *moifture*, *heat*, and *oxygen gas*, be prefent; and that they do not germinate well if they are expofed to [illegible]. Now, in what manner do thefe [illegible] the feed? What are the changes which [illegible]

94 [Phenomena of germination.]

[illegible], that all feeds have one or more cotyledons. These cotyledons contain a quantity of farinaceous matter, laid up on purpofe to fupply the embryo plant with food as foon as it begins to require it. This food, however, muft undergo fome previous preparation, before it can be applied by the plant to the formation or completion of its organs. Now all the phenomena of germination which [illegible], confift in the chemical [illegible] in that food, and the confequent [illegible] of the organs of the plant.

95 [The cotyledons prepare food,]

When a feed is placed in favourable circumftances, it gradually imbibes moifture, and very foon after emits a quantity of carbonic acid gas, even though no oxygen gas be prefent *. This feems to prove, as Mr Cruickfhank has fuppofed, that fome of the water imbibed by the feed is decompofed, that its oxygen combines with part of the carbon of the farina, and goes off in the form of carbonic acid gas, while the hydrogen remains behind, and combines with the ingredients contained in the cotyledon. The firft part of germination, then, confifts in diminifhing the quantity of carbon, and increafing the hydrogen of the farina. If no oxygen gas be prefent, the procefs ftops here, and no germination takes place.

But if oxygen gas be prefent, it is gradually abforbed and retained by the feed; and at the fame time, the farina of the cotyledons affumes a fweet tafte refembling fugar: it is therefore converted into fugar, or fome fubftance analogous to it †. Farina, then, is changed into fugar, by diminifhing its carbon, and augmenting the proportion of its hydrogen and oxygen. This is precifely the procefs of malting, or of converting grain into malt; during which it is well known that there is a confiderable heat evolved; fo much indeed, that in certain circumftances grain improperly kept has even taken fire. We may conclude from this, that during the germination of feeds in the earth there is alfo an evolution of a confiderable portion of heat. This indeed might have been expected, as it ufually ha[illegible] when oxygen gas is abforbed.

So far feems to be the work of chemiftry [illegible] at leaft we have no right to conclude that any other agent interferes; fince *hay*, when it happens to imbibe moifture, exhibits nearly the fame proceffes. Carbonic acid gas is evolved, oxygen gas is abforbed, heat is produced fo abundantly, that the hay often takes fire: at the fame time a quantity of fugar is formed. It is owing to a partial change of the fame kind that old hay generally taftes much fweeter than new hay. Now we have no reafon to fuppofe that any agents peculiar to the vegetable kingdom refide in hay; as all vegetation, and all power of vegetating, are evidently deftroyed.

96 [Which paffes into the radicle.]

But when the farina in the feeds of vegetables is converted into fugar, a number of veffels make their appearance in the cotyledon. The reader will have a pretty diftinct notion of their diftribution, by infpecting fig. 2. Thefe veffels may indeed be detected in many feeds before germination commences, but they become much more diftinct after it has made fome progrefs. Branches from them have been demonftrated by Grew, Malpighi, and Hedwig, paffing into the radicle, and diftributed through every part of it. Thefe evidently carry the nourifhment prepared in the cotyledons to the radicle; for if the cotyledons be cut off even after the proceffes above defcribed are completed, germination, as Bonnet and Senebier afcertained by experiment, immediately ftops. The food therefore is conveyed from the cotyledons into the radicle, the radicle increafes in fize, affumes the form of a *root*, finks down into the earth, and foon becomes capable of extracting the nourifhment neceffary for the future growth of the plant. Even at this period, after the radicle has become a perfect root, the plant, as Senebier afcertained by experiment, ceafes to vegetate if the *cotyledons* be cut off. They are ftill then abfolutely neceffary for the vegetation of the plant.

97 [And converts it into a root.]

98 [Cotyledons become feminal leaves.]

The cotyledons now affume the appearance of leaves, and appear above the ground, forming what are called the *feminal leaves* of the plant. After this the *plumula* gradually increafes in fize, rifes out of the earth, and expands itfelf into branches and leaves. The feminal leaves, foon after this, decay and drop off, and the plant carries on all the proceffes of vegetation without their affiftance.

Mr Eller attempted to fhew, that there is a veffel in feeds which paffes from the cotyledons to the plumula; but later anatomifts have not been able to perceive any fuch veffel. Even Mr Hedwig, one of the moft patient, acute, and fuccefsful philofophers that ever turned their attention to the ftructure of vegetables, could never

* Experiences fur les Vegetaux, ii.

† Mem. Phyfico-Chimique, iii. 41.

‡ Jour. de Phyf. 1789, Decemb.

§ Enc Meth. Phyfiol. Veg. i. 126.

* Gough, Manch. Mem. iv. 15. Cruickfhank, Rollo on Diabetes, 452.

† Ibid.

never diſcover any ſuch veſſel, although he traced the veſſels of the cotyledons even through the radicle. As it does not appear, then, that there is any communication between the cotyledons and the plumula, it muſt follow that the nouriſhment paſſes into the plumula from the radicle: and accordingly we ſee, that the plumula does not begin to vegetate till the radicle has made ſome progreſs. Since the plant ceaſes to vegetate, even after the radicle has been converted into a root, if the cotyledons be removed before the plumula is developed, it follows, that the radicle is inſufficient of itſelf to carry on the proceſſes of vegetation, and that the cotyledons ſtill continue to perform a part. Now we have ſeen already what that part is: they prepare *food* for the nouriſhment of the plant. The root, then, is of itſelf inſufficient for this purpoſe. When the cotyledons aſſume the form of ſeminal leaves, it is evident that the nouriſhment which was originally laid up in them for the ſupport of the embryo plant is exhauſted, yet they ſtill continue as neceſſary as ever. They muſt therefore receive the nouriſhment which is imbibed by the root; they muſt produce ſome changes on it, render it ſuitable for the purpoſes of vegetation, and then ſend it back again to be tranſmitted to the plumula.

99 Which prepare the food ſent from the root.

After the plumula has acquired a certain ſize, which muſt be at leaſt a *line*, if the cotyledons be cut off, the plant, as Mr Bonnet aſcertained by a number of experiments, afterwards repeated with equal ſucceſs by Mr Senebier, does not ceaſe to vegetate, but it continues always a mere pigmy: its ſize, when compared with that of a plant whoſe cotyledons are allowed to remain, being only as 2 to 7*.

* Enc Meth. Phyſiol Veget. 41.

100 Plumula forms the ſtem and leaves.

When the plumula has expanded completely into leaves, the cotyledons may be removed without injuring the plant, and they very ſoon decay of themſelves. It appears, then, that this new office of the cotyledons is afterwards performed by that part of the plant which is above ground.

Thus we have traced the phenomena of germination as far as they have been detected. The facts are obvious; but the *manner* in which they are produced is a profound ſecret. We can neither explain how the food enters into the veſſels, how it is conveyed to the different parts of the plant, how it is depoſited in every organ, nor how it is employed to increaſe the ſize of the old parts, or to form new parts. Theſe phenomena are analogous to nothing in mechanics or chemiſtry. He that attempts to explain them on the principles of theſe ſciences, merely ſubſtitutes new meanings of words inſtead of old ones, and gives us no aſſiſtance whatever in conceiving the proceſſes themſelves. As the ſubſtances employed in vegetation are all material, it is evident that they poſſeſs the properties of matter, and that they are arranged in the plant according to theſe laws. It follows, therefore, that all the changes which take place in the plant are produced according to the known laws of mechanics and chemiſtry. This cannot be diſputed: but it explains nothing; for what we want to know is the *agent* that brings every particle of matter to its proper place, and enables the laws of chemiſtry and mechanics to act only in order to accompliſh a certain end. Who is the agent that acts according to this end? To ſay that it is chemiſtry or mechanics is to pervert the uſe of words. For what are the laws of chemiſtry and mechanics? Are they not certain fixed and unalterable properties of matter? Now, to ſay that a property of matter has an end in view, or that it acts in order to accompliſh ſome deſign, is a downright abſurdity. There muſt therefore be ſome agent in all caſes of germination, which regulates and directs the mechanical and chemical proceſſes, and which therefore is neither a mechanical nor chemical property.

8. When the proceſs of germination is accompliſhed, the plant is complete in all its parts, and capable of vegetating in a proper ſoil, for a time and with a vigour proportional to its nature.

101 Plants compoſed of bark, wood, and pith.

Plants, as every body knows, are very various, and of courſe the ſtructure of each ſpecies muſt have many peculiarities. Trees have principally engaged the attention of anatomiſts, on account of their ſize and the diſtinctneſs which they expected to find in their parts. We ſhall therefore take a tree as an inſtance of the ſtructure of plants; and we ſhall do it the more readily, as the greater number of vegetables are provided with analogous organs, dedicated to ſimilar uſes.

A TREE is compoſed of a *root*, a *trunk*, and *branches*; the ſtructure of each of which is ſo ſimilar, that a general deſcription of their component parts will be ſufficient. Each of them conſiſts of three parts, the *bark*, the *wood*, and the *pith*.

102 Bark,

The BARK is the outermoſt part of the tree. It covers the whole plant from the extremity of the roots to the extremity of the branches. It is uſually of a green colour: if a branch of a tree be cut acroſs, the bark is eaſily diſtinguiſhed from the reſt of the branch by this colour. If we inſpect ſuch a horizontal ſection with attention, we ſhall perceive that the bark itſelf is compoſed of three diſtinct bodies, which, with a little care, may be ſeparated from each other. The outermoſt of theſe bodies is called the *epidermis*, the middlemoſt is called the *parenchyma*, and the innermoſt, or that next the wood, is called the *cortical layers*.

103 Compoſed of epidermis,

The *epidermis* is a thin tranſparent membrane, which covers all the outſide of the bark. It is pretty tough. When inſpected with a microſcope, it appears to be compoſed of a number of ſlender fibres croſſing each other, and forming a kind of network. It ſeems even to conſiſt of different thin retiform membranes, adhering cloſely together. This, at leaſt, is the caſe with the epidermis of the birch, which Mr Duhamel ſeparated into ſix layers. The epidermis, when rubbed off, is reproduced. In old trees it cracks and decays, and new epidermes are ſucceſſively formed. This is the reaſon that the trunks of many old trees have a rough ſurface.

104 Parenchyma,

The *parenchyma* lies immediately below the epidermis; it is of a deep green colour, very tender, and ſucculent. When viewed with a microſcope, it ſeems to be compoſed of fibres which croſs each other in every direction, like the fibres which compoſe a hat. Both in it and the epidermis there are numberleſs interſtices, which have been compared to ſo many ſmall bladders.

105 And cortical layers.

The *cortical layers* form the innermoſt part of the bark, or that which is next to the wood. They conſiſt of ſeveral thin membranes, lying the one above the other; and their number appears to increaſe with the age of the plant. Each of theſe layers is compoſed of longitudinal fibres, which ſeparate and approach each other alternately, ſo as to form a kind of network. The meſhes of this network correſpond in each of the lay-

Vegetables. ers; and they become smaller and smaller in every layer as it approaches the wood. These meshes are filled with a green coloured cellular substance, which has been compared by anatomists to a number of bladders adhering together, and communicating with each other.

106 Wood composed of

The WOOD lies immediately under the bark, and forms by far the greatest part of the trunk and large branches of trees. It consists of concentric layers, the number of which increases with the age of the part. Each of these layers, as Mr Du Hamel ascertained, may be separated into several thinner layers, and these are composed chiefly of longitudinal fibres. Hence the reason that wood may be much more easily split asunder than cut across.

The *wood*, when we inspect it with attention, is not, through its whole extent, the same; the part of it next the bark is much softer and whiter, and more juicy than the rest, and has for that reason obtained a particular name: it has been called the *alburnum* or *aubier*.

107 Alburnum and perfect wood.

The *perfect wood* is browner, and harder, and denser, than the alburnum, and the layers increase in density the nearer they are to the centre. Sir John Hill gave to the innermost layer of wood the name of *corona*, or rather he gave this name to a thin zone which, according to him, lies between the wood and the pith.

108 Pith.

The PITH occupies the centre of the wood. It is a very spongy body, containing a prodigious number of cells, which anatomists have compared to bladders. In young shoots it is very succulent; but it becomes dry as the plant advances, and at last in the large trunks of many trees disappears altogether.

The LEAVES are attached to the branches of plants by their footstalks. [illegible] footstalks a number of [illegible] which [illegible] communicate with each [illegible] of the leaf [illegible] a very curious [illegible] fibres may be obtained separately, by [illegible] in moisture. Every other part of [illegible] may easily be rubbed off, [illegible] constituting [illegible] of the [illegible] there are two layers of these fibres, [illegible] constituted the upper and under surface of the leaf.

The whole leaf is covered with the epidermis of the plant; and this epidermis, as Saussure has shewn, contains in it a great number of glands. The other parts of the [illegible] at least Saussure has [illegible] composed of two different layers. The [illegible] between the fibres of the leaf are filled up by a pulpy-like substance, to which the green colour of the leaf is owing.

Such is a short description of the most conspicuous parts of plants. A more minute account would have been foreign to the subject of the present article.

110 Plants increase in size.

Plants, after they have germinated, do not remain stationary, but are continually increasing in size. A tree, for instance, every season, adds considerably to its former bulk. The root sends forth new shoots, and the old ones become larger and thicker. The same increment takes place in the branches and the trunk. When we examine this increase more minutely, we find that a new layer of wood, or rather of alburnum, has been added to the tree in every part, and this addition has been made just under the bark. We find, too, that a layer of alburnum has assumed the appearance of perfect wood. Besides this addition of vegetable fibre, a great number of leaves have been produced; and the tree puts forth flowers, and forms seeds.

111 Therefore require food.

It is evident from all this, that a great deal of new matter is continually making its appearance in plants. Hence, since it would be absurd to suppose that they *create* new matter, it must follow that they receive it by some channel or other. Plants, then, require food as well as animals. Now, what is this food, and whence do they derive it? These questions can only be answered by an attentive survey of the substances which are contained in vegetables, and an examination of those substances which are necessary for their vegetation. If we could succeed completely, it would throw a great deal of light upon the nature of soils and of manures, and on some of the most important questions in agriculture. But we are far indeed at present from being able to examine the subject to the bottom.

112 Water necessary.

1. In the first place, it is certain that plants will not vegetate without water; for whenever they are deprived of it, they wither and die. Hence the well known use of rains and dews, and the artificial watering of ground. We may conclude, then, that water is at least an essential part of the food of plants.

But many plants grow in pure water; and therefore it may be questioned whether water is not the only food of plants. This opinion was adopted very long ago, and numerous experiments have been made in order to demonstrate it. Indeed, it was the general opinion of the 17th century; and some of the most successful improvers of the physiology of plants, in the 18th century, have embraced it. The most zealous advocates for it were, Van Helmont, Boyle, Bonnet, Duhamel, and Tillet.

113 Supp. the whole food of plants;

Van Helmont planted a willow which weighed five pounds, in an earthen vessel filled with soil previously dried in an oven, and moistened with rain water. This vessel he sunk into the earth, and he watered his willow, sometimes with rain, and sometimes with distilled water. After five years it weighed $169\frac{1}{4}$ lbs. and the earth in which it was planted, when again dried, was found to have lost only two ounces of its original weight. Here, it has been said, was an increase of 164 lb. and yet the only food of the willow was pure water; therefore it follows that pure water is sufficient to afford nourishment to plants. The insufficiency of this experiment to decide the question was first pointed out by Bergman in 1773 *. He shewed, from the experiments of Margraff, that the rain water employed by Van Helmont contained in it as much earth as could exist in the willow at the end of five years. For, according to the experiments of Margraff, 1 lb. of rain water contains 1 gr. of earth †. The growth of the willow, therefore, by no means proves that the earth which plants contain has been formed out of water. Besides, as Mr Kirwan has remarked ‡, the earthen vessel must have often absorbed moisture, from the surrounding earth, impregnated with whatever substance that earth contained; for unglazed earthen vessels, as Hales * and Tillet † have shewn, readily transmit moisture.

* *Opusc.* v. 92.

† *Opusc.* ii. 15. and 19.

‡ *Irish Trans.* v. 150.

* *Veget. Stat.* i. 5.

† *Mem. Par.* 1772. 298.

114 But without reason.

Hence it is evident that no conclusion whatever can be drawn from this experiment; for all the substances which the willow contained, except water, may have been derived from the rain water, the earth in the pot, and the moisture imbibed from the surrounding soil.

The

Vegetation.

The experiments of Duhamel and Tillet are equally inconclusive; so that it is impossible from them to decide the question, Whether water be the sole nourishment of plants or not? We owe the solution of this difficulty to the experiments of Mr Hassenfratz, who pointed out the fallacy of those just mentioned.

He analysed the bulbous roots of hyacinths, in order to discover the quantity of water, carbon, and hydrogen, which they contained; and by repeating the analysis on a number of bulbs, he discovered how much of these ingredients was contained in a given weight of the bulb. He analysed also kidney beans and cress seeds in the same manner. Then he made a number of each of these vegetate in pure water, taking the precaution to weigh them beforehand, in order to ascertain the precise quantity of carbon which they contained. The plants being then placed, some within doors, and others in the open air, grew and flowered, but produced no seed. He afterwards dried them, collecting with care all their leaves and every other part which had dropt off during the course of the vegetation. On submitting each plant to a chemical analysis, he found that the quantity of carbon, which it contained, was somewhat less than the quantity which existed in the bulb or the seed from which the plant had sprung *.

* Ann de Chim. xiii. 158.

Hence it follows irresistibly, that plants growing in pure water do not receive any increase of *carbon;* that the water merely serves as a vehicle for the carbonaceous matter already present, and diffuses it thro' the plant. Water, then, is not the sole food of plants; for all plants during vegetation receive an increase of carbonaceous matter, without which they cannot produce perfect seeds, nor even continue to vegetate beyond a certain time; and that time seems to be limited by the quantity of carbonaceous matter contained in the bulb or the seed from which they grow. For Duhamel found, that an oak which he had raised by water from an acorn, made less and less progress every year. We see, too, that those bulbous roots, such as hyacinths, tulips, &c. which are made to grow in water, unless they be planted in the earth every other year, refuse at last to flower, and even to vegetate; especially if they produce new bulbous roots annually, and the old ones decay.

115 A certain proper.

So far, indeed, is water from being the sole food of plants, that in general only a certain proportion of it is serviceable, too much being equally prejudicial to them as too little. Some plants, it is true, grow constantly in water, and will not vegetate in any other situation; but the rest are entirely destroyed when kept immersed in that fluid beyond a certain time. Most plants require a certain degree of moisture, in order to vegetate well. This is one reason why different soils are required for different plants. Rice, for instance, requires a very wet soil: were we to sow it in the ground on which wheat grows luxuriously, it would not succeed; and wheat, on the contrary, would rot in the rice ground.

We should, therefore, in choosing a soil proper for the plants which we mean to raise, consider the quantity of moisture which is best adapted for them, and choose our soil accordingly. Now, the dryness or moisture of a soil depends upon two things; the nature and proportions of the earths which compose it, and the quantity of rain which falls upon it. Every soil contains at least three earths, silica, lime, and alumina, and sometimes also magnesia. The silica is always in the state of sand. Now soils retain moisture longer or shorter according to the proportions of these earths. Those which contain the greatest quantity of sand retain it the shortest, and those which contain the greatest quantity of alumina retain it longest. The first is a dry, the second a wet soil. Lime and magnesia are intermediate between these two extremes: they render a sandy soil more retentive of moisture, and diminish the wetness of a clayey soil. It is evident, therefore, that, by mixing together proper proportions of these four earths, we may form a soil of any degree of dryness and moisture that we please.

But whatever be the nature of the soil, its moisture must depend in general upon the quantity of rain which falls. If no rain at all fell, a soil, however retentive of moisture it be, must remain dry; and if rain were very frequently falling, the soil must be open indeed, if it be not constantly wet. The proportion of the different earths in a soil, therefore, must depend upon the quantity of rain which falls. In a rainy country, the soil ought to be open; in a dry country, it ought to be retentive of moisture. In the first, there ought to be a greater proportion of sand; in the second, of clay.

11. Almost all plants grow in the earth, and every soil contains at least silica, lime, alumina, and often magnesia. We have seen already that one use of these earths is to administer the proper [illegible] to the vegetables which grow in the soil. [illegible] all plants contain earths as a part of their [illegible] probable that earths also serve as a [illegible] has not yet indeed been shewn, that [illegible] vegetate in pure water do not contain [illegible] quantity of earth; but as earths are absolutely necessary for the perfect vegetation of plants, as they are contained in all plants, and are even found in [illegible], we can scarcely doubt that they are actually imbibed, though only in [illegible]

117 And salts;

12. We [illegible] that all plants contain [illegible] and if we analyse the most fertile soils, and the richest manures, we ne[illegible] them destitute of these substances. Hence it is probable that different salts enter as ingredients into the food of plants. It is probable also, that every plant absorbs particular kinds of salts. Thus sea plants yield soda by analysis, while inland plants furnish potass. The potass contained in plants has indeed been supposed to be the produce of vegetation; but this has not been proved in a satisfactory manner. We find potass in the very juices of plants, even more abundantly than in the vegetable fibres themselves. But this subject is still buried in obscurity; and indeed it is extremely difficult

2

(D) Mr Tennant has ascertained, that magnesia, when uncombined with carbonic acid gas, is injurious to corn when employed as a manure; and that lime, which contains a mixture of magnesia, likewise injures corn.—See *Phil. Trans.* 1799, p. 2. This important fact demonstrates, that earths are not mere vehicles for conveying water to plants.

ficult to make decisive experiments, on account of the very small quantity of potass which most plants contain.

The phosphorus, too, and the iron, and other metals which are found in plants, are no doubt absorbed by them as a part of their food. We may suppose also, that the sulphuric and muriatic acids, and perhaps even the nitric acid, when found in plants, are imbibed by them along with the rest of their aliment.

Nothing is at present known concerning those saline substances which form an essential part of the food of plants; though it has been long remarked that certain salts are useful as manures.

118 And carbon. 13 Water, then, and earths, and perhaps also salts, form a part of the food of plants. But plants contain carbon, which cannot be derived from any of these substances; consequently some substance or other besides, which contains carbon, must constitute a part of the food of plants.

Mr Giobert mixed together the four earths, silica, alumina, lime, magnesia, in the proper proportions, to constitute a fertile soil; and after moistening them with water, planted several vegetables in them; but none of his plants grew well till he moistened the artificial soil with water from a [illegible] *. Now it is known, from the experiments of [illegible], that this water contains carbon; [illegible] evaporated, it constantly left behind it a [illegible] of charcoal †. We know likewise, from a great [illegible] of experiments, that all fertile soils contain a [illegible] quantity of carbonaceous matter; for all of them, when exposed to heat, are susceptible of partial combustion, during which a quantity of carbon [illegible] Thus Fourcroy and Hassenfratz found, that [illegible] fertile soil contained [illegible] of oil; which, [illegible] suppose to con[illegible] 16 [illegible] part of [illegible]. But these [illegible] roots of ve[illegible] con[illegible] the roots of [illegible] of car[illegible]

119 Which must be in a particular state; But [illegible] particular [illegible] as food for plants [illegible] mixed with earths, is not [illegible] immediately, as a manure; yet [illegible] great quantity of carbon. Farther, it appears from the experiments of Mr Hassenfratz, that substances employed as manures produce effects in times proportioned to their degree of putrefaction; those substances which are most putrid producing the most speedy effects, and of course soonest losing their efficacy. Having manured two pieces of the same kind of soil, the one with a mixture of dung and straw highly putrefied, the other with the same mixture newly made, and the straw almost fresh; he observed that, during the first year, the plants which grew on the land manured with the putrefied dung produced a much better crop than the other: but the second year (no new dung being added), the ground which had been manured with the unputrified dung produced the best crop; the same thing took place the third year; after which, both seemed to be equally exhausted *. Here it is evident that the putrified dung acted soonest, and was soonest exhausted. It follows from this, that carbon only acts as a manure when in a particular state of combination; and this state, whatever it may be, is evidently produced by putrefaction. Another experiment of the same chemist renders this truth still more evident. He allowed shavings of wood to remain for about ten months in a moist place till they began to putrefy, and then spread them over a piece of ground by way of manure. The first two years this piece of ground produced nothing more than others which had not been manured at all; the third year it was better, the fourth year still better, the fifth year it reached its maximum of fertility; after which it declined constantly till the ninth, when it was quite exhausted †. Here the effect of the manure evidently depended upon its progress in putrefaction.

* Encyc. Meth. Phys. Veget. p. 275.

† Ann. de Chim. xiv. 56.

* [illegible]

† Ibid. p. 58.

120 And it [illegible] water. Now what is the particular state into which carbon must be reduced before it be fit for the food of plants? This subject has never been examined with attention; the different combinations of carbon having been in a great measure overlooked. And yet it is evident, that it is only by an accurate examination of these combinations, and a thorough analysis of manures, in order to discover what particular combinations of carbon exist in them, and in what the most efficacious manures differ from the rest, that we can expect to throw complete light upon the nature and use of manures, one of the most important subjects to which the farmer can direct his attention. We know, from the experiments of Mr Hassenfratz, that all those manures which act with efficacy and celerity contain carbon in such a state of combination, that it is soluble in water; and that the efficacy of the manure is proportional to the quantity of carbon so soluble. He found that all efficacious manures gave a brown colour to water, and that the water so coloured, when evaporated, left a residuum, which consisted in a great measure of carbon *. He observed, too, that the soil which gives the deepest colour to water, or which contains the greatest quantity of carbon soluble in water, is, other things being the same, the most fertile.

* Ibid. p. 56.

This is not, however, to be understood without limitation; for it is well known that if we employ excessive quantities of manure, we injure vegetation instead of promoting it. This is the reason that plants will not, as Mr Duhamel found by experiment, vegetate in saturated solutions of dung †.

† Mem. Par. 1748.

121 This state not carbonic acid gas; One of the combinations of carbon which is soluble in water, and with which we are best acquainted, is carbonic acid gas. It has been supposed by many philosophers, particularly by Mr Senebier, that this gas, dissolved in water, supplies plants with a great part of their carbon. But Mr Hassenfratz, on making the experiment, found, that the plants which he raised in water, impregnated with carbonic acid gas, differed in no respect from those which grew in pure water, and did not contain a particle of carbon which had not existed in the seeds from which they sprung ‡. This experiment proves, that carbonic acid gas, dissolved in water, does not serve as food for plants. It appears, however, from the experiments of Ruckert, that when plants growing in soil are watered daily with water impregnated with carbonic acid gas, they vegetate faster than when this watering is omitted. He planted two beans in

‡ Ann. de Chim. xiii. 325.

122 Though that gas is useful.

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in pots of equal dimensions, filled with garden mould. One of these was watered almost daily with distilled water, the other with water, every ounce of which was impregnated with half a cubic inch of carbonic acid gas. Both were placed in the open air, but in a situation where they were secure from rain. The bean treated with the water impregnated with carbonic acid gas appeared above ground nine days before the other, and produced 25 beans; whereas the other produced only 15. The same experiment was tried on other plants with equal success †. This shews us that carbonic acid gas is somehow or other useful to plants when they vegetate in mould; but it gives us no information about its mode of acting. Some soils, we know, are capable of decomposing it; for some soils contain the green oxyd of iron: and Gadolin has proved, that such soils have the property of decomposing carbonic acid gas *. Indeed almost all soils contain iron, either in the state of the brown or the green oxyd; and Beaumé has shewn, that oils convert the brown oxyd of iron into the green †. Now dung contains a quantity of oily substance; and this is the case also with rich soils. One use of manures, therefore, may be, to reduce the brown oxyd of iron to the green, that it may be capable of decomposing carbonic acid gas; and the carbon, thus precipitated, doubtless enters into some new combination, in which state it serves as food for plants.

Mr Humbolt has lately proved, that soils have the property of absorbing oxygen. It can scarcely be doubted that this absorption has an influence on vegetation, especially as watering plants with weak solutions of oxy-muriatic acid accelerates vegetation *. But we know too little of the subject at present to be able to specify precisely what that influence is.

123 Food absorbed by the roots.

14. Since the only part of plants which is contiguous to the soil is the root, and since the plant perishes when the root is pulled out of the ground, it is evident that the food of plants must be imbibed by the roots.

When we examine the roots, we do not find them to contain any large opening. The passages by which the food enters are too small for the naked eye. This shews us, that the food can enter plants only in a fluid state; and that consequently every thing which can be rendered useful as food for plants must be previously in a state of solution.

It seems most probable, that the whole, or the greatest part of the food, enters at the extremities of the roots; for Duhamel observed, that the portion of the soil which is soonest exhausted, is precisely that part in which the greatest number of the extremities of roots lies ‡. This shews us the reason why the roots of plants are continually increasing in length. By this means they are enabled, in some measure, to go in quest of nourishment. The extremities of the roots seem to have a peculiar structure adapted for the imbibing of moisture. If we cut off the extremity of a root, it never increases any more in length: therefore its use as a root has been in a great measure destroyed. But it sends out fibres from its sides which act the part of roots, and imbibe food by their extremity. Nay, in some cases, when the extremity of a root is cut off, the whole decays, and a new one is formed in its place. This, as Dr Bell informs us, is the case with the hyacinth †.

Since the food of plants must be in a fluid state, and since no plant will live if it be deprived of moisture, we may conclude that all its food is previously dissolved in water. As for the carbon, we know, that in all active manures it is in such a state of combination, that it is soluble in water. We know, too, that all the salts which we can suppose to make a part of the food of plants, are more or less soluble in water. Lime also is soluble in water, whether it be pure or in the state of a salt; magnesia and alumina may be rendered so by means of carbonic acid gas; and Bergman, Macie, and Klaproth, have shewn, that even silica may be dissolved in water. We can see, therefore, in general, though we have no precise notions of the very combinations which are immediately imbibed by plants, that all the substances which form essential parts of that food *may* be dissolved in water.

124 Dissolved in water.

125 Therefore fluid.

15. Since the food of plants is imbibed by their roots in a fluid state, it must exist in plants in a fluid state; and unless it undergoes alterations in its composition just when imbibed, we may expect to find it in the plant unaltered. If there were any method of obtaining this fluid food from plants before it has been altered by them, we might analyse it, and obtain by that means a much more accurate knowledge of the food of plants than we can by any other method. This plan indeed must fail, provided the food undergoes alteration just when it is absorbed by the roots: but if we consider, that when one species of tree is grafted upon another, each bears its own peculiar fruit, and produces its own peculiar substances, we can scarcely avoid thinking that the great changes, at least which the food undergoes after absorption, are produced, not in the roots, but in other parts of the plant.

If this conclusion be just, the food of plants, after being imbibed by the roots, must be carried to those organs where it is to receive new modifications, and to be rendered fit for being assimilated to the different parts of the plant. There ought therefore to be certain juices continually ascending from the roots of plants; and these juices, if we could get them pure and unmixed with the other juices or fluids which the plant must contain, and which have been secreted and formed from these primary juices, would be, very nearly at least, the food as it was imbibed by the plant. Now during the vegetation of plants, there actually are juices continually ascending from their roots. This juice has been called the *sap*, the *succus communis*, the *lymph* of plants. We shall adopt the first of these names, because it has been most generally received.

The first step towards an accurate knowledge of the food, and of the changes which take place during vegetation, is an analysis of the sap. The sap is most abundant during the spring. At that season, if a cut be made through the bark and part of the wood of some trees, the sap flows out very profusely. The trees are then said to *bleed*. By this contrivance any quantity of sap we think proper may be collected. It is not probable, indeed, that by this method we obtain the ascending sap in all its purity: it is no doubt mixed with the peculiar juices of the plant; but the less progress vegetation has made, the purer we may expect to find it; both because the peculiar juices must be in much smaller quantity, and because its quantity may

† *Crell's Annals*, 1788. ii. 399.

* *Ibid.* 1791. i. 53.

† *Kirw.*, *Irish Tr.* v. 150.

* *Ingenhousz.*

‡ *Physique des Arbres*, ii. 239.

† *Manch. Mem.* ii. 412.

 may be supposed to be greater. We should therefore examine the sap as early in the season as possible, and at all events before the leaves have expanded.

For the most complete set of experiments hitherto made upon the sap, we are indebted to Mr Vauquelin. An account of his experiments has been published in the 31st volume of the *Annales de Chimie*. He has neglected to inform us of the state of the tree when the sap which he analysed was taken from it; so that we are left in a state of uncertainty with respect to the purity of the sap: but from the comparison which he has put it in our power to draw between the state of the sap at different successive periods, we may in some measure obviate this uncertainty.

He found that 1039 parts of the sap of the ulmus campestris, or common elm, were composed of

1027.567 water and volatile matter,
9.553 acetite of potass,
1.062 vegetable matter,
0.818 carbonat of lime,

Besides some slight traces of sulphuric and muriatic acids.

On analysing the same sap somewhat later in the season, Mr Vauquelin found the quantity of vegetable matter a little increased, and that of the carbonat of lime and acetite of potass diminished. Still later in the season the vegetable matter was farther increased, and the other two ingredients farther diminished. The acetite of potass, in 1000 parts of this third sap, amounted to 8.615 parts.

If these experiments warrant any consequence to be drawn from them, they would induce us to suppose that the carbonat of lime and acetite of potass were contained in the [illegible] ascending sap, [illegible] part at least of the vegetable matter [illegible] from the peculiar juices altering [illegible] organs of the plant; for the two salts [illegible] and the vegetable matter increased [illegible] of the sap [illegible]. Now [illegible] ought to have taken place on the [illegible] become more and more mixed [illegible] of the sap [illegible] supposing [illegible] this conclusion have any validity, it follows [illegible] that carbonat of lime and acetite of potass are absorbed by plants as a part of their food. Now these salts [illegible] be dissolved in water [illegible] may be dissolved in water [illegible]. This shews us how water [illegible] acid may be useful to plants vegetating in a proper soil, while it is useless to those that vegetate in pure water. In the pure water there is no carbonat of lime to be dissolved; and therefore carbonic acid gas cannot enter into a combination which renders it proper for becoming the food of plants. Part of the vegetable matter was precipitated from the sap by alcohol. This part seems to have been gummy. Now gums we know are produced by vegetation.

The sap of the fagus sylvatica, or beech, contained the following ingredients.

Water,
Acetite of lime with excess of acid,
Acetite of potass,
Gallic acid,
Tan,
A mucous and extractive matter,
Acetite of alumina.

Although Mr Vauquelin made two different analyses of this sap at different seasons, it is impossible to draw any satisfactory conclusions from them, as he has not given us the proportions of the ingredients. It seems clear that the ga[illegible] tan were combined together; for the sap tasted like the infusion of oak bark. The quantity of each of these ingredients increased as vegetation advanced; for the colour of the second sap collected later was much deeper than that of the first. This shews us that these ingredients were produced by vegetation, and that they did not form a part of the ascending sap. Probably they were derived from the bark of the tree. The presence of alumina, and the absence of carbonic acid gas, would seem to indicate that all plants do not imbibe the very same food.

The sap of the carpinus sylvestris contains water, acetite of potass, acetite of lime, sugar, mucilage, vegetable extract. It cannot be doubted that the sugar and the mucilage are the produce of vegetation.

The sap of the betula alba, or common birch, contains water, sugar, vegetable extract, acetite of lime, acetite of alumina, and acetite of potass.

These experiments are curious, and certainly add to the precision of our notions concerning the food of plants; but they are not decisive enough to entitle us to draw conclusions. They would seem to shew, either that acetite of potass and lime are a part of the food of plants, or at least some substances which have the property of assuming these combinations.

16. These experiments lead to the conclusion that acetous acid forms a component part of the sap. Now it is not easy to suppose that this substance is actually absorbed by the roots in the state of acetous acid. The thing might be determined by examining the mould in which plants grow. This examination indeed has been performed; but no chemist has ever found acetous acid, at least in any sensible quantity. Is it not probable, then, that the food, after it is imbibed, is somewhat modified and altered by the roots? In what manner this is done we cannot say, as we know very little about the vascular structure of the roots. We may conclude, however, that this modification is nearly the same in most plants: for one plant may be engrafted on another, and each continue to produce its own peculiar products; which could not be, unless the proper substances were conveyed to the digestive organs of all. There are several circumstances, however, which render the modifying power of the roots somewhat probable. The strongest of these is the nature of the ingredients found in the sap. It is even possible that the roots may, by some means or other, throw out again some part of the food which they have imbibed as excrementitious. This has been suspected by several physiologists; and there are several circumstances which render it probable. It is well known that some plants will not vegetate well after others; and that some again vegetate unusually well when planted in ground where certain plants had been growing. These facts, without doubt, may be accounted for on other principles. If there be any excrementitious matter emitted by the roots, it is much more probable that this happens in the last stage of vegetation. That is to say, when the food, after digestion, is applied to the purposes which the root requires. But the fact ought to be supported by experiments, otherwise it cannot be admitted.

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112 Whether food is altered by the roots.

17. The

Vegetation.

17. The sap, as Dr Hales has shewn us, ascends with a very considerable force. It issued during the bleeding season with such impetuosity from the cut end of a vine branch, that it supported a column of mercury 32½ inches high *.

* Veg. Stat. i. 105.

129 Sap ascends

Now what is the particular channel through which the sap ascends, and what is the cause of the force with which it moves? These are questions which have excited a great deal of the attention of those philosophers who have made the physiology of vegetables their particular study; but the examination of them is attended with so many difficulties that they are very far from being decided.

It is certain that the sap flows from the roots towards the summit of the tree. For if in the bleeding season a number of openings be made in the tree, the sap begins first to flow from the lowest opening, then from the lowest but one, and so on successively, till at last it makes its appearance at the highest of all. And when Duhamel and Bonnet made plants vegetate in coloured liquors, the colouring matter, which was deposited in the wood, appeared first in the lowest part of the tree, and gradually ascended higher and higher, till at last it reached the top of the tree, and tinged the very leaves.

It seems certain, too, that the sap ascends through the wood, and not through the bark of the tree: for a plant continues to grow even when stript of a great part of its bark; which could not happen if the sap ascended through the bark. When an incision, deep enough to penetrate the bark, and even part of the wood, is carried quite round a branch, provided the wound be covered up from the external air, the branch continues to vegetate as if nothing had happened; which could not be the case if the sap ascended between the bark and the wood. It is well known, too, that in the bleeding season little or no sap can be got from a tree unless our incision penetrate deeper than the bark.

131 Not by the parenchyma;

If the sap ascended thro' the parenchyma of plants, as some physiologists have supposed, since there is a communication between every part of that organ, it is evident that the tree ought to bleed whenever any part of the parenchyma is wounded. But this is not the case. Consequently the sap does not ascend through the parenchyma. Besides, if the supposition were true, the sap, from the very structure of the parenchyma, must ascend in the same manner as water through a sponge; and in that case could not possibly possess the force with which we know that it ascends. But if the sap is not found in the parenchyma, as is now well known to be the case, it must, of necessity, be confined in particular vessels; for if it were not, it would undoubtedly make its appearance there. Now what are the vessels through which the sap ascends?

But in vessels.

Grew and Malpighi, the first philosophers who examined the structure of plants, took it for granted that ascended [illegible]

[illegible] a tube; and succeeding observers have been equally unsuccessful. The conjecture therefore of Malpighi and Grew, about the nature and use of these fibres, remains totally unsupported by any proof. Duhamel has even gone far to overturn it altogether. For he found that these woody fibres are divisible into smaller fibres, and these again into still smaller; and even, by the assistance of the best microscopes, he could find no end of this subdivision *. Now granting these fibres to be vessels, it is scarcely possible, after this, to suppose that the sap really moves through tubes, whose diameters are almost infinitely small. There are, however, vessels in plants which may easily be distinguished by the help of a small microscope, and even, in many cases, by the naked eye. These were seen, and distinctly described, by Grew and Malpighi. They consist of a fibre twisted round like a corkscrew. If we take a small cylinder of wood, and wrap round it a slender brass wire, so closely that all the rings of the wire touch each other, and if, after this, we pull out the wooden cylinder altogether, the brass wire thus twisted will give us a very good representation of these vessels. If we take hold of the two ends of the brass wire thus twisted, and pull them, we can easily draw out the wire to a considerable length. In the same manner, when we lay hold of the two extremities of these vessels, we can draw them out to a great length. Malpighi and Grew finding them always empty, concluded that they were intended for the circulation of the air through the plant, and therefore gave them the name of *tracheæ*, which word is used to denote the *windpipe* of animals. These *tracheæ* are not found in the bark; but Hedwig has shewn that they are much more numerous in the wood than was supposed; and that they are of very different diameters; and Reichel has demonstrated that they go to the [illegible] branches, and spread through every leaf. He has [illegible], too, that they contain sap; and Hedwig has proved that the notion which generally prevailed of their containing nothing but [illegible] the larger tracheæ [illegible] their sap as soon [illegible] they are inspected [illegible] appear empty †. Is it not probable, [illegible] not certain, from the discoveries [illegible] physiologists, that the tracheæ [illegible] vessels of plants? [illegible] experiments both of Reichel and Hedwig, that [illegible] almost all the [illegible] of plants [illegible] only to their structure [illegible].

* Physique des Arbres, i. 57.

† [illegible]

133 Why it ascends.

But by what [illegible] to ascend in these vessels? [illegible] to ascend, but to move with very [illegible] force, as Hales has shewn, sufficient to overcome the pressure of 43 feet perpendicular of water ‡.

‡ Veget. Stat. i. 107.

134 Hypothesis of Grew, Malpighi, and De la Hire.

Grew ascribed this phenomenon to the levity of the sap; which, according to him, entered the plant in the state of a very light vapour. But this opinion will not bear the slightest examination. Malpighi supposed that the sap was made to ascend by the contraction and dilatation of the air contained in the air vessels. But [illegible] tracheæ are air vessels, [illegible] could only ascend [illegible] place; which is [illegible] were to wave every [illegible] objection of that kind, the hypothesis would not account for the circulation of the sap, unless the sap vessels be provided with valves. Now the experiments of Hales and Duhamel shew that no valves can possibly exist in them. For branches imbibe moisture nearly equally

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equally by either end; and consequently the sap moves with equal facility both upwards and downwards, which it could not do were there valves in the vessels. Besides, it is known, from many experiments, that we may convert the roots of a tree into the branches, and the branches into the roots, by covering the branches with earth, and exposing the roots to the air. Now this would be impossible if the sap vessels were provided with valves. The same remarks overturn the hypothesis of Mr de la Hire, which is merely that of Malpighi, expressed with greater precision, and with a greater parade of mechanical knowledge. Like Borelli, he placed the ascending power of the sap in the parenchyma. But his very experiments, had he attended to them with care, would have been sufficient to shew the imperfection of his theory.

The greater number of philosophers (for it is needless to mention those who, like Perrault, had recourse to fermentation, nor those who introduced the weight of the atmosphere) have ascribed the motion of the sap to *capillary attraction.*

Ascribed to capillary attraction

There exists a certain attraction between many solid bodies and liquids; in consequence of which, if these solid bodies be formed into small tubes, the liquid enters them, and rises in them to a certain height. But this is perceptible only when the diameter of the tube is very small; [illegible] the attraction has been denominated *capillary*. We know that there is such an attraction between vegetable fibres and watery liquids. For such [illegible] through [illegible] vegetable [illegible] probable, therefore, that the food of plants enters the roots in consequence of the capillary attraction which [illegible] between the sap vessels and the liquid imbibed. [illegible] attraction then, [illegible] well [illegible] of moisture [illegible] But will it account [illegible] the ascent of the sap, [illegible] have [illegible] But we [illegible] decide [illegible] attrac[illegible] of the [illegible] not extend, or at [illegible] at greater distance [illegible] It has been demonstrated [illegible] by the capillary attraction [illegible] but of a slender film of it; and Clairaut has shewn that this film is situated at the lowermost extremity of the tube (G). This film attracts the liquid with a certain force; and if this force be greater than the cohesion between the particles of the liquid, part enters the tube, and continues to enter, till the quantity above the attracting film of the tube just equals, by its weight, the excess of the capillary attraction between the tube and the liquid, above the cohesion of the liquid. The quantity of water therefore in the tube is pretty nearly the measure of this excess; for the attracting film is probably very minute.

It has been demonstrated, that the heights to which liquids rise in capillary tubes, are inversely as the diameter of the tube. Consequently the smaller the diameter of the tube, the greater is the height to which the liquid will rise. But the particles of water are not infinitely small; therefore whenever the diameter of the tube is diminished beyond a certain size, water cannot ascend in it, because its particles are now larger than the bore of the tube. Consequently the rise of water in capillary tubes must have a limit: if they exceed a certain length, how small soever their bore may be, water will either not rise to the top of them, or it will not enter them at all. We have no method of ascertaining the precise height to which water would rise in a capillary tube, whose bore is just large enough to admit a single particle of water. Therefore we do not know the limit of the height to which water may be raised by capillary attraction. But whenever the bore is diminished beyond a certain size, the quantity of water which rises in it is too small to be sensible. We can easily ascertain the height which water cannot exceed in capillary tubes before this happens: and if any person calculate, he will find that this height is not nearly equal to the length of the sap vessels of many plants. But besides all this, we see in many plants very long sap vessels, of a diameter too large for a liquid to rise in them a single foot by capillary attraction, and yet the sap rises in them to very great heights.

If any person says that the sap vessels of plants gradually diminish in diameter as they ascend; and that, in consequence of this contrivance, they act precisely as an indefinite number of capillary tubes, one standing upon another, the inferior serving as a reservoir for the superior: we answer, that the sap may ascend by that means to a considerable height; but certainly not in any greater quantity than if the whole sap vessel had been precisely of the bore of its upper extremity. For the quantity of sap raised must depend upon the bore of the upper extremity, because it must all pass through that extremity. The quantity of sap, too, on that supposition, must diminish the farther we go from the root, because the bore of the sap vessels is constantly diminishing; the ascending force must also diminish, because it is, in all cases, proportional to the quantity of water raised. Now neither of these, as Dr Hales has demonstrated, is true.

157 Is it refuted.

But farther, if the sap moved only in the vessels of plants by capillary attraction, it would be so far from flowing out at the extremity of a branch, with a force sufficient to overcome the pressure of a column of water 43 feet high, that it could not flow out at all. It would be impossible in that case for any such thing as the bleeding of trees ever to happen.

If we take a capillary tube, of such a bore that a liquid will rise in it six inches, and after the liquid has risen to its greatest height, break it short three inches from the bottom, none of the liquid in the under half flows over. The tube, thus shortened, continues indeed full, but not a single particle of liquid ever escapes from it. And how is it possible for it to escape? The film,

(G) The action of all the other films, of which the tube is composed, on the water, as far as it is measured by its effect, is nothing at all. For every particle of water in the tube (except those attracted by the undermost film) is attracted upwards and downwards by the same number of films: it is therefore precisely in the same state as if it were not attracted at all.

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It is impossible therefore to account for the motion of the sap in plants by any mechanical or chemical principles whatever; and he, who ascribes it to these principles has not formed to himself any clear or accurate conception of the subject. We know indeed that heat is an agent; for Dr Walker found that the ascent of the sap is much promoted by heat, and that after it had begun to flow from several incisions, cold made it give over flowing from the higher orifices while it continued to flow at the lower*. But this cannot be owing to the dilating power of heat: for unless the sap vessels of plants were furnished with valves (and they have no valves), dilatation would rather retard than promote the ascent of the sap. Consequently the effect of heat can give us no assistance in explaining the ascent of the sap upon mechanical and chemical principles.

133 The vessels must contract. We must therefore ascribe it to some other cause: the vessels themselves must certainly act. Many philosophers have seen the necessity of this, and have accordingly ascribed the ascent of the sap to *irritability*. But the first person who gave a precise view of the manner in which the vessels probably act was Saussure. He supposes that the sap enters the open mouths of the vessels, at the extremity of the roots; that these mouths then contract, and by that contraction propel the sap upwards; that this contraction gradually follows the sap, pushing it up from the extremity of the root to the summit of the plant. In the mean time the mouths are receiving new sap, which in the same manner is pushed upwards †. Whether we suppose the contraction to take place precisely in this manner or not, we can scarcely deny that it must take place; but by what means it is impossible to say. The agents cannot precisely resemble the muscles of animals; because the whole tube, however cut or maimed, still retains its contracting power, and because the contraction is performed with equal readiness in every direction. It is evident, however, that they must be the same in kind. Perhaps the particular structure of the vessels may fit them for their office. Does ring after ring contract its diameter? The contracting agents, whatever they are, seem to be excited to act by some stimulus communicated to them by the sap. This capacity of being excited to action is known in physiology by the name of *irritability*; and there are not wanting proofs that plants are possessed of it. It is well known that different parts of plants move when certain substances act upon them. Thus the flowers of many plants open at sunrise, and close again at night. Linnæus has given us a list of these plants. Des Fontaines has shewn that the stamina and antheræ of many plants exhibit distinct motions ‡. Dr Smith has observed, that the stamina of the barberries are thrown into motions when touched §. Roth has ascertained that the leaves of the drosera longifolia and rotundifolia have the same property. Mr Coulon, too, who has adopted the opinion that the motion of the sap in plants is produced by the contraction of vessels, has even made a number of experiments in order to shew this contraction. But the fact is, that every one has it in his power to make a decisive experiment. Simply cutting a plant, the *euphorbia peplis* for instance, in two places, so as to separate a portion of the stem from the rest, is a complete demonstration that the vessels actually do contract. For whoever makes the experiment, will find that the milky juice of that plant flows out at both ends so completely, that if afterwards we cut the portion of the stem in the middle, no juice whatever appears. Now it is impossible that these phenomena could take place without a contraction of the vessels; for the vessels in that part of the stem which has been detached cannot have been *more* than full; and their diameter is so small, that if it were to continue unaltered, the capillary attraction would be more than sufficient to retain their contents, and consequently not a drop could flow out. Since, therefore, the whole liquid escapes, it must be driven out forcibly, and consequently the vessels must contract.

* Phil. Trans. l.

† Encyc. Meth. Phys. Veget. p 297.

‡ Mem. Par. 1787.

§ Phil. Trans. lxxviii.

It seems pretty plain, too, that the vessels are excited to contract by various stimuli; the experiments of Coulon and Saussure render this probable, and an observation of Dr Smith Barton makes it pretty certain. He found that plants growing in water vegetated with much greater vigour, provided a little camphor was thrown into the water*. 139 In consequence of stimuli.

18. Besides the sap which ascends upwards towards the leaves, they contain also another fluid, known by the name of *succus proprius*, or peculiar juice. This juice differs very considerably in different plants. It seems to be the sap altered by some process or other, and fitted for the various purposes of vegetation. That it flows from the leaves of the plant towards the roots, appears from this circumstance, that whenever we make an incision into a plant, into whatever position we put it, much more of the succus proprius flows from that side of the wound which is next the leaves and branches, than from the other side; and this happens even though the leaves and branches be held undermost †. When a ligature is tied round a plant, a swelling appears above, but not below the ligature.

† Bell. Manch. Mem. ii. 402.

The vessels containing the peculiar juice are found in all the parts of the plant. Hedwig, who has examined the vessels of plants with very great care, seems to consider them as of the same structure with the tracheæ. The peculiar juice is easily known by its colour and its consistence. In some plants it is green, in some red, in many milky. It cannot be doubted that its motion in the vessels is performed in the same way as that of the sap.

140 In the leaves. 19. It appears, then, that the sap ascends to the leaves, that there it undergoes certain alterations, and is converted into the peculiar juices; which, like the blood in animals, are afterwards employed in forming the various substances found in plants. Now the changes which the sap undergoes in the leaves, provided we can trace them, must throw a great deal of light upon the nature of vegetation.

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141 Part of the sap perspires thro' the leaves.

No sooner has the sap arrived at the leaves, than a great part of it is thrown off by evaporation. The quantity thus perspired bears a very great proportion to the moisture imbibed. Mr Woodward found that a sprig of mint in 77 days imbibed 2558 grains of water, and yet its weight was only increased 15 grains *; therefore it must have given out 2543 grains. Another branch, which weighed 127 grains, increased in weight 128, and it had imbibed 14190 grains. Another sprig, weighing 76 grains, growing in water mixed with earth, increased in weight 168 grains, and had imbibed 10731 grains of water. These experiments demonstrate the great quantity of matter which is constantly leaving the plant. Dr Hales found that a cabbage transmitted daily a quantity of moisture equal to about half its weight; and that a sun flower, three feet high, transmitted in a day 1 lb. 14 oz. avoirdupois †. He shewed, that the quantity of transpiration in the same plant was proportional to the surface of the leaves, and that when the leaves were taken off, the transpiration nearly ceased ‡. By these observations, he demonstrated that the leaves are the organs of transpiration. He found, too, that the transpiration was nearly confined to the day, very little taking place during the night §; that it was much promoted by heat, and stopped by rain and frost ‖. And Millar ¶, Guettard *, and Senebier, have shewn that the transpiration is also very much promoted by sunshine.

* Phil. Trans. N° 253.

† Veget. Stat i. 5. and 15.

‡ Ib.

§ Ibid. 5.

‖ Ibid. 27. and 48.

¶ Ibid. 22.

* Mem. Par. 1748.

The quantity of moisture imbibed by plants depends very much upon what they transpire: the reason is evident; when the vessels are once filled with sap, if none be carried off, no more can enter; and, of course, the quantity which enters must depend upon the quantity emitted.

In order to discover the nature of the transpired matter, Hales placed plants in large glass vessels, and by that means collected a quantity of it †. He found that it resembled pure water in every particular, excepting only that it sometimes had the odour of the plant. He remarked, too, as Guettard and Du Hamel did after him, that when kept for some time it putrefied, or at least acquired a stinking smell. Senebier subjected a quantity of this liquid to a chemical analysis.

† Ibid. 49.

143 Its nature,

He collected 12030 grains of it from a vine during the months of May and June. After filtration he gradually evaporated the whole to dryness. There remained behind two grains of residuum. These two grains consisted of nearly ¼ grain of carbonat of lime, $\frac{1}{11}$ grain of sulphat of lime, ½ grain of matter soluble in water, and having the appearance of gum, and ½ grain of matter which was soluble in alcohol, and apparently resinous. He analyzed 60768 grains of the same liquid, collected from the vine during the months of July and August. On evaporation he obtained 2¼ grains of residuum, composed of ½ grain of carbonat of lime, ½ grain of sulphat of lime, ¼ grain of mucilage, and ½ grain of resin. The liquid transpired by the *aster novae Angliae* afforded precisely the same ingredients ‡.

‡ Enc. Method. Phys. Veget. 287.

144 And quantity.

Senebier attempted to ascertain the proportion which the liquid transpired bore to the quantity of moisture imbibed by the plant. But it is easy to see that such experiments are liable to too great uncertainties to be depended on. His method was as follows: He plunged the thick end of the branch on which he made the experiment into a bottle of water, while the other end, containing all its leaves, was thrust into a very large glass globe. The apparatus was then exposed to the sunshine. The quantity imbibed was known exactly by the water which disappeared from the bottle, and the quantity transpired was judged of by the liquid which condensed and trickled down the sides of the glass globe. The following table exhibits the result of his experiments:

Plants.	*Imbibed.*	*Perspired.*	*Time.*
Peach	100 gr.	35 gr.	
Ditto	210	90	
Ditto	220	120	
Mint	200	90	2 days
Ditto	575	120	10
Rasp	725	560	2
Ditto	1232	765	2
Peach	710	295	1
Apricot	210	180	1

In some of his experiments no liquid at all was condensed. Hence it is evident that the quantity of matter transpired cannot be deduced from these experiments. The mouth of the glass globe does not seem to have been accurately closed; the air within it communicated with the external air: consequently the quantity condensed must have depended entirely upon the state of the external air, the heat, &c.

The first great change, then, which takes place upon the sap after it arrives at the leaves, is the evaporation of a great part of it; consequently what remains must be very different in its proportions from the sap. The leaves seem to have particular organs adapted for throwing off part of the sap by transpiration. For the experiments of Guettard *, Duhamel †, and Bonnet ‡, shew that it is performed chiefly by the upper surfaces of leaves, and may be nearly stopped altogether by varnishing the upper surface.

* Mem. Par. 1748.

† Physique des Arbres, i. 138.

‡ Traité de l'usage des feuilles, 1. Mem.

145 Why the leaves fall off.

The leaves of plants become gradually less and less fit for this transpiration; for Senebier found, that when all other things are equal, the transpiration is much greater in May than in September *. Hence the reason that the leaves are renewed annually. Their organs become gradually unfit for performing their functions, and therefore it is necessary to renew them. Those trees which retain their leaves during the winter, were found by Hales and succeeding physiologists to transpire less than others. It is now well known that these trees also renew their leaves.

* En. Meth. 285.

20. Leaves have also the property of absorbing carbonic acid gas from the atmosphere.

146 Leaves absorb carbonic acid gas.

We are indebted for this very singular discovery to the experiments of Dr Priestley, though he himself did not discover the truth, and though he even refused to acknowledge it when it was pointed out by others. It has been long known, that when a candle has been allowed to burn out in any quantity of air, no candle can afterwards be made to burn in it. In the year 1771 Dr Priestley made a sprig of mint vegetate for ten days in contact with a quantity of such air; after which he found that a candle would burn in it perfectly well ¶. This experiment he repeated frequently, and found that it was always attended with the same result. According to the opinion at that time universally received, that the

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the burning of candles rendered air impure by communicating phl[illegible]ston to [illegible] he concluded from it, that plants, whi[illegible] state, absorb phlogiston.

Carbonic [illegible] was at that time supposed to contain phlog[illegible]ton. It was natural, therefore, to suppose that it would afford nourishment to plants, since they had the property of absorbing phlogiston from the atmosphere Dr P[illegible]rcival had published a set of experiments; by which he endeavoured to shew that this was actually the case.

These experiments induced Dr Priestley, in 1776, to consider the subject with more attention. But as, in all the experiments which he made, the plants confined in carbonic acid gas very soon died, he concluded, that carbonic acid gas was not a food, but a poison to plants *. Mr Henry of Manchester was led, in 1784, probably by the contrariety of these results, to examine the subject. His experiments, which were published in the Manchester Transactions †, perfectly coincided with those of Dr Percival. For he found, that carbonic acid gas, so far from killing plants, constantly promoted their growth and vigour. Meanwhile Mr Senebier was occupied at Geneva with the same subject; and he published the result of his researches in his *Memoires Physico-chymique* about the year 1780. His experiments shewed, in the clearest manner, that carbonic acid gas is used by plants as food. The same thing was supported by Ingenhousz in his second volume. The experiments of Saussure the Son, published in 1797, have at last put the subject beyond the reach of dispute. From a careful comparison of the experiments of these philosophers, it will not be difficult for us to discover the various phenomena, and to reconcile all the seeming contradictions which occur in them. The facts are as follows:

* On Air i. 100.

† ii 341.

Mr Saussure has shewn, that plants will not vegetate when totally deprived of carbonic acid gas. They vegetate indeed well enough in air which has been previously deprived of carbonic acid gas; but when a quantity of lime was put into the glass vessel which contained them, they no longer continued to grow, and the leaves in a few days fell off ‡. The air, when examined, was found to contain no carbonic acid gas. The reason of this phenomenon is, that plants (as we shall see afterwards) have the power of forming and giving out carbonic acid in certain circumstances; and this quantity is sufficient to continue their vegetation for a certain time. But if this new formed gas be also withdrawn, by quicklime, for instance, which absorbs it the instant it appears, the leaves droop, and refuse to perform their functions. Carbonic acid gas, then, applied to the leaves of plants, is *essential* to vegetation.

‡ Ann. de Chim xxiv 145. 148.

147
Decompose it and emit the oxygen;

Dr Priestley, to whom we are indebted for many of the most important facts relative to vegetation, observed, in the year 1778, that plants, in certain circumstances, emitted oxygen gas ||; and Ingenhousz very soon after discovered that this gas is emitted by the *leaves* of plants, and only when they are exposed to the bright light of day. His method was to plunge the leaves of different plants into vessels full of water, and then expose them to the sun, as Bonnet, who had observed the same phenomenon, though he had given a wrong explanation of it, had done before him. Bubbles of oxygen gas very soon detached themselves from the leaves, and were collected in an inverted glass vessel *. He observed, too, that it was not a matter of indifference what kind of water was used. If the water, for instance, had been previously boiled, little or no oxygen gas escaped from the leaves; river water afforded but little gas; but pump water was the most productive of all †.

|| On Air, iii 204.

* Ingenhousz on Veget. i 15 &c.

† Ibid. 83.

Senebier proved, that if the water be previously deprived of all its air by boiling, the leaves do not emit a particle of air; that those kinds of water which yield most air, contain in them the greatest quantity of carbonic acid gas; that leaves do not yield any oxygen when plunged in water totally destitute of carbonic acid gas; that they emit it abundantly when the water, rendered unproductive by boiling, is impregnated with carbonic acid gas; that the quantity of oxygen emitted, and even its purity, is proportional to the quantity of carbonic acid gas which the water contains; that water impregnated with carbonic acid gas gradually loses the property of affording oxygen gas with leaves; and that whenever this happens, all the carbonic acid gas has disappeared; and on adding more carbonic acid gas the property is renewed ‡. These experiments prove, in a most satisfactory manner, that the oxygen gas which the leaves of plants emit depends upon the presence of carbonic acid gas; that the leaves absorb carbonic acid gas, decompose it, give out the oxygen, and retain the carbon.

‡ Enc. Methol. Phys. Veget. 181.

148
But during the day only.

We now see why plants will not vegetate without carbonic acid gas. They absorb it and decompose it; but this process goes on only when the plants are exposed to the light of day. Therefore we may conclude, that the absorption and decomposition of carbonic acid gas is confined to the day, and that light is an essential agent in the decomposition. Probably it is by its agency, or by its entering into combination with the oxygen, that this substance is enabled to assume the gaseous form, and to separate from the carbon.

If we reason from analogy, we shall conclude, that during this process a quantity of caloric [illegible]; and that therefore no increase of temperature takes place, but rather the contrary. This may be one reason why the operation takes place only during the day.

149
In this way plants may acquire much carbon.

It is extremely probable, that plants by this process acquire the greatest part of the carbonaceous matter which they contain. If we compare the quantity of carbon contained in plants vegetating in the dark, where this process cannot go on, with the quantity which those plants contain which vegetate in the usual manner, we shall perceive a very conspicuous difference. Chaptal found that a byssus, which was vegetating in the dark, contained only $\frac{1}{10}$ of its weight of carbonaceous matter; but the same plant, after being made to vegetate in the light for 30 days, contained $\frac{1}{4}$th of its weight of carbonaceous matter *. Hassenfratz ascertained, that plants growing in the dark contain much more water, and much less carbon and hydrogen, than plants growing in the light. Senebier analysed both with the same result. Plants growing in the dark yielded less hydrogen gas and oil: their resinous matter was to that of plants growing in the light as 2 to 5,5, and their moisture as 13 to 6; they contain even one-half less of fixed matters.

* Mem. Par. 1786.

It is evident, however, that this absorption and decomposition of carbonic acid gas does not depend upon the

Vegeta. the light alone. The nature of the sap has also its influence; for Hassenfratz found, that the quantity of carbon did not increase when plants vegetated in pure water. Here the sap seems to have wanted that part which combines with and retains the carbon; and which therefore is by far the most important part of the food of plants. Upon the discovery and mode of applying this substance, whatever it is, the improvements in agriculture must in a great measure depend.

If we consider the difference in the proportion of carbonaceous matter in plants vegetating in the dark and in the usual manner, we can scarcely avoid concluding that the quantity of carbonic acid gas absorbed by plants is considerable. To form an estimate of it, would require a set of experiments performed in a very different manner from any hitherto made. The stems and branches of plants vegetating in a rich soil should be confined within a large glass globe, the inside of which ought to have no communication with the external air. A very small stream of carbonic acid gas should be made occasionally to flow into this globe, so as to supply the quantity that may appear necessary; and there should be a contrivance to carry off and examine the air within the globe when it increases beyond a certain quantity. Experiments conducted in this manner would probably throw a great deal of light upon this part of vegetation, and enable us to calculate the quantity of carbonic acid decomposed, and the quantity of oxygen emitted by plants; to compare these with the waste of oxygen by the respiration of animals and combustion, and to see whether or not they balance each other.

150 The decomposition performed by the parenchyma. Senebier has ascertained, that the decomposition of the carbonic acid takes place in the parenchyma. He found, that the epidermis of a leaf would, when separated, give out no air; neither would the nerves in the same circumstances; but upon trying the parenchyma, thus separated from its epidermis and part of its nerves, it continued to give out oxygen as before †. He remarked also, that every thing else being equal, the quantity of oxygen emitted, and consequently of carbonic acid decomposed, is proportional to the thickness of the leaf; and this thickness depends upon the quantity of parenchyma.

That the decomposition is performed by peculiar organs, is evident from an experiment of Ingenhousz. Leaves cut into small pieces continued to give out oxygen as before; but leaves pounded in a mortar lost the property entirely. In the first case, the peculiar structure remained; in the other, it was destroyed. Certain experiments of Count Rumford, indeed, are totally incompatible with this conclusion; and they will naturally occur to the reader as an unsurmountable objection. He found, that dried leaves, black poplar, fibres of raw silk, and even glass, when plunged into water, gave out oxygen gas by the light of the sun. But when Senebier repeated these experiments, not one of them would succeed ‡; and we have attempted them with the same bad success. The Count must have been missed by something which he has not mentioned.

Thus we have seen, that when the sap arrives at the leaves, great part is thrown off by evaporation, and that the nature of the remainder is considerably altered by the addition of a quantity of carbon: but these are by no means all the alterations produced upon the sap in the leaves.

† Enc. Meth. Phys. Veget. 180.

‡ Ann. de Chim. i. 15.

21. Plants will not vegetate unless atmospheric air or oxygen gas have access to their leaves. This was rendered probable by those philosophers who, about the end of the 17th century, turned their attention particularly towards the physical properties of the air: But Mr Ingenhousz was perhaps the first of the modern chemists who put it beyond doubt. He found that carbonic acid gas, azot, and hydrogen gas, destroyed plants altogether, unless they were mixed with atmospheric air or oxygen gas. He found also, that plants grew very well in oxygen gas and in atmospheric air *. These experiments are sufficient to shew, that oxygen gas is necessary to vegetation. The leaves of plants seem to absorb it; and most probably this absorption takes place only in the night. We know, at least, that in germination light is injurious to the absorption of oxygen gas; and therefore it is probable that this is the case also in vegetation.

22. The leaves of plants not only absorb carbonic acid gas and oxygen gas, but water also. This had been suspected in all ages: the great effect which dew, slight showers, and even wetting the leaves of plants, have in recruiting their strength, and making them vegetate with vigour, are so many proofs that the leaves imbibe moisture from the atmosphere. Hales rendered this still more probable, by observing, that plants increase considerably in weight when the atmosphere is moist; and Mr Bonnet put the matter beyond doubt in his *Researches concerning the Use of the Leaves*. He shewed, that leaves continue to live for weeks when one of their surfaces is applied to water; and that they not only vegetate themselves, but even imbibe enough of water to support the vegetation of a whole branch, and the leaves belonging to it. He discovered also, that the two surfaces of leaves differ very considerably in their power of imbibing moisture; that in trees and shrubs, the under surface possesses almost the whole of the property, while the contrary holds in many of the other plants; the kidney bean for instance. 152 [illegible] water,

These facts prove, not only that the leaves of plants have the power of absorbing moisture, but also that the absorption is performed by very different organs from those which emit moisture; for these organs lie on different sides of the leaf. If we consider that it is only during the night that the leaves of plants are moistened with dew, we can scarcely avoid concluding, that, except in particular cases, it is during the night that plants imbibe almost all the moisture which they do imbibe.

23. During the night the leaves of plants emit carbonic acid gas. This fact was first demonstrated by Mr Ingenhousz †, and it has been since confirmed by every philosopher who has attended to the subject. 153 And emit carbonic acid gas.

Thus we have seen that the leaves of plants perform very different operations at different times. During the day they are giving out moisture, absorbing carbonic acid gas, and emitting oxygen gas; during the night, on the contrary, they are absorbing moisture, giving out carbonic acid gas, and absorbing oxygen gas.

The emission of the carbonic acid gas seems to be the consequence of the decomposition of water; either of the water which is already contained in the sap, or

* Palliau

† On Vegetables, i. 47 and 11. Palliau.

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of that which the leaves imbibe during the night; but which of the two, it is impossible to determine, nor is it of much consequence. We may conclude that this is the case, because it takes place during the germination of the seed, where all the circumstances seem to be perfectly analogous. The water is decomposed; its oxygen is combined with part of the carbon which had been absorbed during the day, and the hydrogen enters into new combinations in the sap. It appears, also, that this decomposition of water depends in a good measure upon the quantity of oxygen gas absorbed; for Dr Ingenhousz found, that when plants are confined in oxygen gas, they emit more carbonic acid gas than when they are confined in common air †.

† Ingenhousz ii.

154 Sap converted by these processes into the peculiar juice.

To describe in what manner these decompositions take place, is impossible; because we neither know precisely the substances into which the sap has been converted by the operations performed during the day, nor the new substances formed by the operations of the night. We only see the elementary substances which are added and subtracted; which is far from being sufficient to give us precise notions concerning the chemical changes and the affinities by which these changes are produced. We have reason, however, to conclude, that during the day the carbon of the sap is increased, and that during the night the hydrogen and oxygen are increased; but the precise new substances formed are unknown to us. Nor let any one suppose that the increase of the hydrogen, and of the oxygen of the sap, is the same thing as the addition of a quantity of water. Far from it. The substances into which the sap is converted have been enumerated in the last chapter; almost all of them consist chiefly of carbon, hydrogen, and oxygen, and yet none of them has the smallest resemblance to water. In water, oxygen and hydrogen are already combined together in a certain proportion; and this combination must be broken before these elementary bodies can enter into those triple compounds with carbon, of which a great part of the vegetable products consist. We have not the smallest conception of the manner in which these triple combinations are formed, and as little of the manner in which the bodies which compose vegetable substances are combined together. The combination may, for any thing we know to the contrary, be very complicated, though it consists only of three ingredients, and analogy leads us to suppose, that it actually is very complicated: for in chemistry it may be considered as a truth, to which at present few or no exceptions are known, that bodies are decomposed with a facility inversely as the simplicity of their composition: that is to say, that those bodies which consist of the fewest ingredients are most difficultly decomposed, and that those which are formed of many ingredients are decomposed with the greatest facility.

Neither let any one suppose, that the absorption of carbonic acid gas, during the day, is balanced by the quantity emitted during the night, and that therefore there is no increase of carbon: for Ingenhousz has shewn, that the quantity of oxygen gas emitted during the day is much greater than the carbonic acid gas emitted during the night; and that in favourable circumstances, the quantity of oxygen gas in the air surrounding plants is very much increased, and the carbonic acid gas diminished; so much so, that both Dr Priestley and Dr Ingenhousz found, that air which had been spoiled by a lighted candle, or by animals, was rendered as good as ever by plants. Now we know, that combustion and respiration diminish the oxygen gas, and add carbonic acid gas to air; therefore vegetation, which restores the purity of air altered by these processes, must increase the oxygen, and diminish the carbonic acid gas of that air: consequently the quantity of carbonic acid gas absorbed by plants during the day is greater than the quantity emitted by them during the night, and of course the carbon of the sap is increased in the leaves.

It is true, that when plants are made to vegetate for a number of days in a given quantity of air, its ingredients are not found to be altered. Thus Hassenfratz ascertained, that the air in which young chesnuts vegetated for a number of days together, was not altered in its properties, whether the chesnuts were vegetating in water or in earth *. And Saussure the Younger proved, that pease growing for ten days in water did not alter the surrounding air †. But this is precisely what ought to be the case, and what must take place, provided the conclusions which we have drawn be just. For if plants only emit oxygen gas, by absorbing and decomposing carbonic acid gas, it is evident, that unless carbonic acid gas be present, they can emit no oxygen gas; and whenever they have decomposed all the carbonic acid gas contained in a given quantity of air, we have no longer any reason to look for their emitting any more oxygen gas; and if the quantity of carbonic acid gas emitted during the night be smaller than that absorbed during the day, it is evident, that during the day the plant will constantly decompose all the acid which had been formed during the night. By these processes, the mutual changes of day and night compensate each other; and they are prevented from more than compensating each other by the forced state of the plant. It is probable, that when only part of a plant is made to vegetate in this forced state, some *carbonated sap* (if we may be allowed the expression) is supplied by the rest of the plant; and that, therefore the quantity of carbonic acid gas emitted during the night may bear a nearer proportion to that emitted in a state of nature, than that of the absorption of fixed air can possibly do. And probably, even when the whole plant is thus confined, the nightly process goes on for a certain time at the expence of the carbon already in the sap; for Hassenfratz found, that in these cases the quantity of carbon in the plant, after it had vegetated for some time in the dark, was less than it had been when it began to vegetate *. This is the reason that plants growing in the dark, when confined, absorb all the oxygen gas, and emit an equal quantity of carbonic acid gas: and whenever this has happened, they die; because then neither the daily nor nightly processes can go on.

* Ann. de Chim. xiii. 325

† Ibid. xxiv.

* Ann de Chim. xiii. 188.

24. Certain changes are also produced on the sap in the leaves by the action of light; and these changes seem to be in some measure independent, or at least different from the absorption and decomposition of carbonic acid gas, in which light, as we have seen, acts an important part.

155 Green colour of plants produced by light.

The green colour of plants is owing entirely to their vegetating in the light; for when they vegetate in the dark they are white; and when exposed to the light, they acquire a green colour in a very short time, in what-

whatſoever ſituation they are placed, even though plunged in water, provided always that oxygen be preſent; for Mr Gough has ſhewn, that light without oxygen has not the power of producing the green colour *. In what manner this change is operated, cannot, in the preſent limited ſtate of our knowledge, be aſcertained. We know too little about the properties of light to be able even to conjecture with any plauſibility. We know indeed, that part of the light is abſorbed by green plants; but this will not account for the phenomenon. When dilated, it amounts to no more than this, that plants which have grown in the dark reflect all the rays of light; while thoſe which vegetate in the light reflect the green and abſorb the others. The very mention of this phenomenon is enough to ſhew us, that we have not advanced far enough to be able to explain it.

* Manch. Memoirs, iv. 501.

Etiolated (E) plants want ſomething, or poſſeſs ſomething peculiar; and it is on this ſomething that the phenomenon depends. But what is this ſomething? The ſudden appearance of the green colour is rather againſt the ſuppoſition, that it is owing to any ſpecific change in the qualities of the ſap.

Senebier has obſerved, that when plants are made to vegetate in the dark, their etiolation is much diminiſhed by mixing a little hydrogen gas with the air that ſurrounds them *. Ingenhouſz had already remarked, that when a little hydrogen gas is added to the air in which plants vegetate, even in the light, it renders their verdure deeper †; and he ſeems to think alſo, that he has proved by experiments, that plants abſorb hydrogen gas in theſe circumſtances ‡. Mr Humbolt has obſerved, that the poa annua and compreſſa, plantago lanceolata, trifolium arvenſe, cheiranthus cheiri, lichen verticillatus, and ſeveral other plants which grow in the galleries of mines, retain their green colour even in the dark, and that in theſe caſes the air around them contains a quantity of hydrogen gas. Theſe facts are ſufficient to ſhew that there is ſome connection between the green colour of plants and the action of hydrogen gas on them; but what that connection is, it is impoſſible at preſent to ſay.

* Enc. Method Phyſ. Veget. 77.

155. By theſe different changes which go on in the leaves, the nature of the ſap is altogether changed. It is now converted into what is called the *peculiar juice*, and is fit for being aſſimilated to the different parts of the plant, and for being employed in the formation of thoſe ſecretions which are neceſſary for the purpoſes of the vegetable economy.

156 Leaves the digeſting organs of plants.

The leaves, therefore, may be conſidered as the digeſting organs of plants, and as equivalent in ſome meaſure to the ſtomach and lungs of animals. The leaves conſequently are not mere ornaments; they are the moſt important parts of the plant. Accordingly we find, that whenever we ſtrip a plant of its leaves, we ſtrip it entirely of its vegetating powers till new leaves are formed. It is well known, that when the leaves of plants are deſtroyed by inſects, they vegetate no longer, and that their fruit never makes any further progreſs in ripening, but decays and dries up. Even in germination no progreſs is made in the growth of the ſtem till the ſeed leaves appear. As much food indeed is laid up in the cotyledons as advances the plant to a certain ſtate, the root is prepared, and made ready to perform its functions; but the ſap which it imbibes muſt be firſt carried to the ſeed leaves, and digeſted there, before it be proper for forming the plumula into a ſtem. Accordingly if the ſeed leaves are cut off, the plant refuſes to vegetate.

Vegetation.

How are produced.

It will be very natural to aſk, If this be true, how come the leaves themſelves to be produced? Even if no anſwer could be given to this queſtion, it could not overturn a ſingle fact which has been formerly mentioned, nor affect a ſingle concluſion as far as it has been fairly deduced from theſe facts. We know that the leaves exiſt long before they appear; they have been traced even five years back. They are completely formed in the bud, and fairly rolled up for evolution, many months before that ſpring in which they expand. We know, too, that if we take a bud, and plant it properly, it vegetates, forms to itſelf a root, and becomes a complete plant. It will not be ſaid, ſurely, that in this caſe the bud imbibes nouriſhment from the earth; for it has to form a root before it can obtain nouriſhment in that manner; and this root cannot be formed without nouriſhment. Is not this a demonſtration that the bud contains, already laid up in itſelf, a ſufficient quantity of nouriſhment, not only to develope its own organs, but alſo to form new ones. This we conſider as a ſufficient anſwer to the objection. During the ſummer, the plant lays up a ſufficient quantity of nouriſhment in each bud, and this nouriſhment is afterwards employed in developing the leaves. This is the reaſon that the leaves make their appearance, and that they grow during the winter, when the plant is deprived of its organs of digeſtion.

Hence we ſee why the branch of a vine, if it be introduced into a hothouſe during the winter, puts forth leaves and vegetates with vigour, while every other part of the plant gives no ſigns of life. Hence alſo the reaſon that the inoculation of plants ſucceeds (F).

If a tree be deprived of its leaves, new leaves make their appearance, becauſe they are already prepared for that purpoſe: but what would be the conſequence if a tree were deprived of its leaves and of all its buds for five

(E) Plants of a white colour, from vegetating in the dark, are called *etiolated*, from a French word which ſignifies a *ſtar*, as if they grew by *ſtar light*.

(F) Hence alſo the cauſe of another well known phenomenon. The ſap flows out of trees very readily in ſpring before the leaves appear, but after that the bleeding ceaſes altogether. It is evident that there can be ſcarcely any circulation of ſap before the leaves appear; for as there is no outlet, when the veſſels are once full, they can admit no more. It appears, however, from the bleeding, that the roots are capable of imbibing, and the veſſels of circulating, the ſap with vigour. Accordingly, whenever there is an outlet, they perform their functions as uſual, and the tree bleeds; that is, they ſend up a quantity of ſap to be digeſted as uſual: but as there are no digeſting organs, it flows out, and the tree receives no injury, becauſe the ſap that flows out would not have been imbibed at all, had it not been for the artificial opening. But when the digeſtive organs appear, the tree will not bleed; becauſe theſe organs require all the ſap, and it is conſtantly flowing to them.

five years back? That plants do not vegetate without leaves, is evident from an experiment of Duhamel. He stript the bark off a tree in stripes, so as to leave five or six rings of it at some distance from each other, with no bark in the intervals. Some of these rings had buds and leaves; these increased considerably in size, but one ring which had none of these remained for years unaltered.

158 26. The peculiar juice thus formed in the leaves is carried by vessels intended for that use to all the parts of the plant, in order to be employed for the purposes of vegetation;—to increase the wood, the bark, the roots; to prepare the seeds, lay up nourishment for the buds, and to repair the decayed parts of the system, or form new ones.

If we had any method of obtaining this peculiar juice in a state of purity, the analysis of it would throw a great deal of light upon vegetation; but this is scarce possible, as we cannot extract it without dividing at the same time the vessels which contain the sap. In many cases, however, the peculiar juice may be known by its colour; and then its analysis may be performed with an approach towards accuracy. The experiments made on such juices have proved, as might have been expected, that they differ very considerably from each other, and that every plant has a juice peculiar to itself. Hence it follows, that the processes which go on in the leaves of plants must differ at least in degree, and that we have no right to transfer the conclusions deduced from experiments on one species of plants to those of another species. It is even probable, that the processes in different plants are not the same in kind; for it is not reasonable to suppose, that the phenomena of vegetation in an agaric or a boletus are precisely the same as those which take place in trees and in larger vegetables, on which alone experiments have hitherto been made.

To attempt any general account of the ingredients of the peculiar juice of plants, is at present impossible. We may conclude, however, from the experiments of Chaptal, that it contains the *vegetable fibre* of wood, either ready formed, or very nearly so; just as the blood in animals contains a substance which bears a strong resemblance to the muscular fibres.

When oxy-muriatic acid was poured into the peculiar juice of the euphorbia, which in all the species of that singular genus is of a milky colour and consistency, a very copious white precipitate fell down. This powder, when washed and dried, had the appearance of fine starch, and was not altered by keeping. It was neither affected by water nor alkalies. Alcohol, assisted by heat, dissolved two thirds of it; which were again precipitated by water, and had all the properties of resin. The remaining third part possessed the properties of the *woody fibre*. Mr Chaptal tried the same experiment on the juices of a great number of other plants, and he constantly found that oxy-muriatic acid precipitated from them *woody fibre*. The seeds of plants exhibited exactly the same phenomenon; and a greater quantity of woody fibre was obtained from them than from an equal portion of the juices of plants *. These experiments are sufficient to shew, that the proper juices of plants contain their nourishment ready prepared, nearly in the state in which it exists in the seed for the use of the young embryo.

* Ann. de Chim. xxi. 285.

The peculiar juices of plants, then, contain more carbon, hydrogen, and oxygen, and less water, and probably lime also, than the sap. They are conveyed to every part of the plant; and all the substances which we find in plants, and even the organs themselves, by which they perform their functions, are formed from them. But the thickest veil covers the whole of these processes; and so far have philosophers hitherto been from removing this veil, that they have not even been able to approach it. All these operations, indeed, are evidently chemical decompositions and combinations; but we neither know what these decompositions and combinations are, nor the instruments in which they take place, nor the agents by which they are regulated.

Vegetation.

159 Its uses.

160 Plants decay and die.

27. Such, as far as we are acquainted with them, are the changes produced by vegetation. But plants do not continue to vegetate for ever; sooner or later they decay, and wither, and rot, and are totally decomposed. This change indeed does not happen to all plants at the end of the same time. Some live only for a single season, or even for a shorter period; others live two seasons, others three, others a hundred or more; and there are some plants which continue to vegetate for a thousand years. But sooner or later they all cease to live; and then those very chemical and mechanical powers which had promoted vegetation combine to destroy the remains of the plant. Now, What is the cause of this change? Why do plants die?

This question can only be answered by examining with some care what it is which constitutes the *life* of plants; for it is evident, that if we can discover what that is which constitutes the life of a plant, it cannot be difficult to discover what constitutes its death.

161 Phenomena of vegetable life.

Now the phenomena of vegetable life are in general called *vegetation*. As long as a plant continues to vegetate, we say that it lives; when it ceases to vegetate, we conclude that it is dead.

The life of vegetables, however, is not so intimately connected with the phenomena of vegetation, that they cannot be separated. Many seeds may be kept for years without giving any symptom of vegetation; yet if they vegetate when put into the earth, we say that they possess life; and if we would speak accurately, we must say also, that they possessed life even before they were put into the earth; for it would be absurd to suppose that the seed *acquired* life merely by being put into the earth. In like manner, many plants decay, and give no symptoms of vegetation during winter; yet if they vegetate when the mild temperature of spring affects them, we consider them as having lived all winter. The life of plants, then, and the phenomena of vegetation, are not precisely the same thing; for the one may be separated from the other, and we can even suppose the one to exist without the other. Nay, what is more, we can, in many cases, *decide*, without hesitation, that a vegetable is not dead, even when no vegetation appears; and the proof which we have for its life is, that it *remains unaltered*; for we know that when a vegetable is dead, it soon changes its appearance, and falls into decay.

Thus it appears that the *life* of a vegetable consists in two things. 1. In remaining unaltered, when circumstances are unfavourable to vegetation; 2. In exhibiting

Vegetation. hibiting the phenomena of vegetation when circumstances are favourable. When neither of these two things happens, we say that a vegetable is dead.

The phenomena of vegetation have been enumerated above. They consist in the formation or expansion of the organs of the plant, in the taking in of nourishment, in carrying it to the leaves, in digesting it, in distributing it through the plant, in augmenting the bulk of the plant, in repairing decayed parts, in forming new organs when they are necessary, in producing seeds capable of being converted into plants similar to the parent. The *cause* of these phenomena, whatever it may be, is the *cause* also of *vegetable life*.

All the substances which have been enumerated in the first part of the article CHEMISTRY, *Suppl.* together with their compounds and component parts, possess certain qualities in common; in consequence of which, a term has been invented which includes them all. This term is *matter*. Now these common qualities may all ultimately be resolved into certain attractions and repulsions which these substances exert. These qualities may be said, without any impropriety, to be *essential to matter*; because every body to which we give the name of *matter* possesses them; and if any body were to be deprived of these qualities, it could no longer be included under the denomination *matter*. In short, the word *matter* comprehends under it certain qualities; every substance which possesses these qualities is called *matter*; and no other substance except these can receive the name of *matter* without altering the meaning of the word.

162 Not reducible to the laws of matter. The attractions and repulsions of matter have been examined with care; and the changes which they produce have been ascertained with considerable accuracy. They have even been reduced to general principles under the name of [illegible]. Whenever any change is observed, if that change be a result of a mechanical or chemical law, we say that the agent is *matter*; but if [illegible] these laws, or if it be incompatible with these laws, we must say, unless we would pervert the meaning of words altogether, that the agent is not *matter*.

Now it cannot be disputed [illegible] the phenomena of life in vegetables [illegible] with the laws of mechanics and chemistry. The motion of the sap, for instance, [illegible] the contraction of the vessels; and the contraction of vessels, on the application of stimuli, is incompatible with the laws of chemistry, because no decomposition takes place; and of mechanics, because a much greater force is generated than the generating body itself possessed. The evolution of the organs of vegetables, the reparation of decayed organs, the formation of new ones to supply the place of the old, the production of seeds capable of producing new plants, the constant similarity of individuals of the same species;—these, and many other well known phenomena, cannot be reduced under mechanical and chemical laws. The cause of life, then, in plants, is a *substance* (for we can form no conception of an agent which is not a substance) which does not act according to the laws of mechanics and chemistry,

163 Consequently owing to an immaterial cause.

and which consequently is *not matter*. We shall therefore, till a better name be chosen, denominate it the *vegetative principle* (G).

164 Nature of the vegetative principle. The nature of the *vegetative principle* can only be deduced from the phenomena of vegetation. It evidently follows a fixed plan, and its actions are directed to promote the good of the plant. It has a power over matter, and is capable of directing its attraction and repulsions, in such a manner as to render them the instruments of the formation, and improvement, and preservation of the plant. It is capable also of generating substances endowed with powers similar to itself. The plan according to which it acts, displays the most consummate wisdom and foresight, and a knowledge of the properties of matter infinitely beyond what man can boast.

165 Whether endowed with consciousness. Metaphysicians have thought proper to divide all substances into two classes, *matter* and *mind*. If we follow this division, the vegetative principle, as it is not *material*, must undoubtedly be ranked under *mind*. But if *consciousness* and *intelligence* be considered as essential to mind, which is the case according to their definition, we cannot give the vegetative principle the name of *mind*, because it has not been proved that it possesses consciousness and intelligence. It acts indeed according to a fixed plan, which displays the highest degree of intelligence; but this plan may belong, not to the vegetative principle itself, but to the Being who formed that principle. We can conceive it to have been endowed by the Author of Nature with peculiar powers, which it must always exert according to certain fixed laws; and the phenomena of vegetation *may be* the result of this mode of acting. This, as far as we can see, is not impossible. It must be shewn to be impossible by every person who wishes to prove that plants possess consciousness and intelligence; for the proofs of that consciousness can only be deduced from the design which the actions of plants manifest. Those philosophers who have ascribed consciousness and intelligence to plants, have founded their belief principally on certain actions which plants perform on the application of stimuli. But these actions prove nothing more than what cannot be denied, that there exists a vegetative principle, which is not material, and which has certain properties in common with the living principles of animals; but whether or not this vegetative principle possesses consciousness and intelligence, is a very different question, and must be decided by very different proofs. We do not say that the heart of an animal is conscious, because it continues to beat on the application of proper stimuli for some time after it has been separated from the rest of the body.

166 Death of plants. The death of plants, if we can judge from the phenomena, is owing, not to the vegetative principle leaving them, but to the organs becoming at last altogether unfit for performing their functions, and incapable of being repaired by any of the powers which that principle possesses. The changes which vegetable substances undergo after death come now to be examined. They shall form the subject of the ensuing chapter.

CHAP.

(G) Physiologists have usually given it the name of *living principle*. We would have adopted that name, if it had not been too general for our purpose.

CHAP. III. OF THE DECOMPOSITION OF VEGETABLE SUBSTANCES.

NOT only entire plants undergo decompofition after death, but certain vegetable fubftances alfo, whenever they are mixed together, and placed in proper circumftances, mutually decompofe each other, and new com-
167 Vegetable decompofitions, pound fubftances are produced. These mutual decompofitions, indeed, are naturally to be expected: for as all vegetable fubftances are compofed of feveral ingredients, differing in the ftrength of their affinity for each other, it is to be fuppofed that, when two fuch fubftances are mixed together, the divellent affinities will, in many cafes, prove ftronger than the quiefcent; and therefore decompofition, and the formation of new compounds, muft take place: juft as happens when the acetite of lead and fulphat of potafs are mixed together.

Thefe mutual decompofitions of vegetable fubftances are by no means fo eafily traced, or fo readily explained, as the mutual decompofitions of neutral falts; partly on account of the number of fubftances, whofe affinities for each other are brought into action, and partly becaufe we are ignorant of the manner in which the ingredients of vegetable fubftances are mutually combined.

168 Called FERMENTATION. Chemifts have agreed to give thefe mutual decompofitions which take place in vegetable fubftances the name of *fermentation*; a word firft introduced into chemiftry by Van Helmont *; and the new fubftances produced they have called the *products* of fermentation. All the phenomena of fermentation lay for many years concealed in the completeft darknefs, and no chemift was bold enough to hazard even an attempt to explain them. They were employed, however, and without hefitation too, in the explanation of other phenomena; as if giving to one procefs, the name of another of which we are equally ignorant, could, in reality, add any thing to our knowledge. The darknefs which enveloped thefe phenomena, has lately begun to difperfe; but they are ftill furrounded with a very thick mift; and we muft be much better acquainted with the compofition of vegetable fubftances, and the mutual affinities of their ingredients, than we are at prefent, before we can explain them in a fatisfactory manner.

* *Stahl, Fundament Chem.* i. 224.

169 Division of them. The vegetable fermentations or decompofitions may be arranged under five heads; namely, that which produces *bread*, that which produces *wine*, that which produces *beer*, that which produces *acetous acid* or *vinegar*, and the *putrefactive* fermentation, or that which produces the fpontaneous decompofition of decayed vegetables. Thefe fhall be the fubject of the five following fections. In order to avoid long titles, we fhall give to the firft three fections the name of the new fubftances produced by the fermentation.

SECT. I. *Of Bread.*

170 Difcovery of bread. SIMPLE as the manufacture of bread may appear to us who have been always accuftomed to confider it as a common procefs, its difcovery was probably the work of ages, and the refult of the united efforts of men, whofe fagacity, had they lived in a more fortunate period of fociety, would have rendered them the rivals of Ariftotle or of Newton.

The method of making bread fimilar to ours was known in the Eaft at a very early period; but neither the precife time of the difcovery, nor the name of the perfon who publifhed it to the world, has been preferved. We are certain that the Jews were acquainted with it in the time of Mofes: for in Exodus * we find a prohibition to ufe leavened bread during the celebration of the paffover. It does not appear, however, to have been known to Abraham; for we hear in his hiftory of cakes frequently, but nothing of leaven. Egypt, both from the nature of the foil and the early period at which it was civilized, bids faireft for the difcovery of making bread. It can fcarcely be doubted, that the Jews learned the art from the Egyptians The Greeks affure us, that they were taught the art of making bread by the god Pan. We learn from Homer that it was known during the Trojan war †. The Romans were ignorant of the method of making bread till the year 580, after the building of Rome, or 200 years before the commencement of the Chriftian era ‡. Since that period the art has never been unknown in the fouth of Europe; but it made its way to the north very flowly, and even at prefent in many northern countries fermented bread is but very feldom ufed.

* Ch. xii. v. 15.

† *Iliad*, ix. 216.

‡ *Plin.* l. xviii. cap. 11.

The only fubftance well adapted for making bread, we mean *loaf bread*, is wheat flour, which is compofed of four ingredients; namely, gluten, ftarch, albumen, and a *fweet mucous matter*, which poffeffes nearly the properties of fugar, and which is probably a mixture of fugar and mucilage. It is to the gluten that wheat flour owes its fuperiority to every other as the bafis of bread. Indeed, there are only two other fubftances at prefent known of which good loaf bread can be made; thefe are *rye* and *potatoes*. The rye loaf is by no means fo well raifed as the wheat loaf; and potatoes will not make bread at all without particular management. Potatoes, previoufly boiled and reduced to a very fine tough pafte by a rolling pin, muft be mixed with an equal weight of potato ftarch. This mixture, baked in the ufual way, makes a very white, well raifed, pleafant bread. We are indebted for the procefs to Mr Permentier. Barley-meal perhaps might be fubftituted for ftarch. — 171 Subftance which make bread.

The baking of bread confifts in mixing wheat flour with water, and forming it into a pafte. The average proportion of thefe is two parts of water to three of flour. But this proportion varies confiderably, according to the age and the quality of the flour. In general, the older and the better the flour is, the greater is the quantity of water required. If the pafte, after being thus formed, be allowed to remain for fome time, its ingredients gradually act upon each other, and the pafte acquires new properties. It gets a difagreeable four tafte, and a quantity of gas (probably carbonic acid gas) is evolved. In fhort, the pafte ferments (H). Thefe changes do not take place without water; that liquid, therefore, is a neceffary agent. Poffibly it is decompofed by the action of the ftarch upon it; for when ftarch is diluted with water, it gradually becomes four. The gluten, too, is altered, either by the action of the water on it, or of the ftarch; for if we examine the pafte after — 172 Baking of bread.

(H) It was from this procefs that Van Helmont transferred the word *fermentation* into chemiftry.

Bread.

after it has undergone fermentation, the gluten is no longer to be found. If paste, after standing for a sufficient time to ferment, be baked in the usual way, it forms a loaf full of eyes like our bread, but of a taste so sour and unpleasant that it cannot be eaten. If a small quantity of this old paste, or *leaven* as it is called, be mixed with new made paste, the whole begins to ferment in a short time; a quantity of gas is evolved; but the glutinous part of the flour renders the paste so tough, that the gas cannot escape; it therefore causes the paste to swell in every direction: and if it be now baked into loaves, the immense number of air bubbles imprisoned in every part renders the bread quite full of eyes, and very light. If the precise quantity of leaven necessary to produce the fermentation, and no more, has been used, the bread is sufficiently light, and has no unpleasant taste; but if too much leaven be employed, the bread has a bad taste; if too little, the fermentation does not come on, and the bread is too compact and heavy. To make good bread with leaven, therefore, is very difficult.

The ancient Gauls had another method of fermenting bread. They formed their paste in the usual way; and instead of leaven, mixed with it a little of the *barm* which collects on the surface of fermenting beer*. This mixture produced as complete and as speedy a fermentation as leaven; and it had the great advantage of not being apt to spoil the taste of the bread. About the end of the 17th century, the bakers in Paris began to introduce this practice into their processes. The practice was discovered, and exclaimed against; the faculty of medicine, in 1688, declared it prejudicial to health; and it was not till after a long time that the bakers succeeded in convincing the public that bread baked with *barm* is superior to bread baked with leaven. In this country the bread has for these many [illegible]

What is the barm which produces these effects? The question is curious and important; but we are not able to answer it completely. Mr Henry of Manchester has concluded, from a number of very interesting experiments, that the only useful part of barm is carbonic acid gas, and that this gas therefore is the real fermenter of paste ‡.

‡ Manch. Mem. ii. 262.

That the barm of beer, in its usual state, contains carbonic acid gas, cannot be doubted; and that carbonic acid gas acts as a ferment, the experiments of Mr Henry prove decisively. But that the only active part of barm is carbonic acid gas, and nothing but carbonic gas, is extremely doubtful, or rather we are certain that it is not true. It has been customary with the bakers of Paris to bring their barm from Flanders and Picardy in a state of dryness. When skimmed off the beer, it is put into sacks, and the moisture allowed to drop out; then these sacks are subjected to a strong pressure, and when the barm is dry it is made up into balls †. Now, in this state, it is not to be supposed that bubbles of carbonic acid can remain entangled in the barm; they must have been squeezed out by the press, and by the subsequent formation of the barm into balls: yet this barm, when moistened with water, ferments the bread as well as new barm.

† Enc. Meth. t. i. 249.

Bread.

171 Heat of the oven.

After the bread has fermented, and is properly raised, it is put into the oven previously heated, and allowed to remain till it be baked. The mean heat of an oven, as ascertained by Mr Tillet, is 448°*. The bakers do not use a thermometer; but they judge that the oven is arrived at the proper heat when flour thrown on the floor of it becomes black very soon without taking fire. We see, from Tillet's experiment, that this happens at the heat of 448°.

* Enc. Meth. ii. 275.

172 Loss of weight sustained in it.

When the bread is taken out of the oven, it is found to be lighter than when put in; as might naturally have been expected, from the evaporation of moisture, which must have taken place at that temperature. Mr Tillet, and the other commissioners who were appointed to examine this subject in consequence of a petition from the bakers of Paris, found that a loaf, which weighed before it was put into the oven 4.625 lbs. after being taken out baked, weighed, at an average, only 3.813 lbs. or 0.812 lb. less than the paste. Consequently 100 parts of paste lose, at an average, 17.34 parts, or somewhat more than $\frac{1}{6}$th by baking*. They found, however, that this loss of weight was by no means uniform, even with respect to those loaves which were in the oven at the same time, of the same form, and in the same place, and which were put in and taken out at the same instant. The greatest difference in these circumstances amounted to .2889, or 7.5 parts in the hundred, which is about $\frac{1}{13}$th of the whole. This difference is very considerable, and it is not easy to say to what it is owing. It is evident, that if the paste has not all the same degree of moisture, and if the barm be not accurately mixed through the whole, if the fermentation of the whole be not precisely the same, that these differences must take place. Now it is needless to observe how difficult it is to perform all this completely. The French commissioners found, as might indeed have been expected, that other things being equal, the loss of weight sustained is proportional to the extent of surface of the loaf, and to the length of time that it remains in the oven; that is to say, the smaller the extent of the external surface, or, which is the same thing, the nearer the loaf approaches to a globular figure, the smaller is the loss of weight which it sustains; and the longer it continues in the oven, the greater is the loss of weight which it sustains. Thus a loaf which weighed exactly 4 lbs. when newly taken out of the oven, being replaced as soon as weighed, lost, in ten minutes, .125 lb. of its weight, and in ten minutes more it again lost .0625 lb †.

* Ibid. 275

† Ibid. p. 276.

Loaves are heaviest when just taken out of the oven; they gradually lose part of their weight, at least if not kept in a damp place, or wrapt round with a wet cloth (x). Thus Mr Tillet found that a loaf of 4 lbs. after being kept for a week, wanted .3125, or nearly $\frac{1}{13}$th of its original weight ‡.

‡ Ibid.

Properties of bread.

When bread is newly taken out of the oven, it has a peculiar, and rather pleasant smell, which it loses by keeping; as it does also the peculiar taste by which new bread is distinguished. This shews us, that the bread undergoes chemical changes; but what these changes are, or what the peculiar substance is to which the odour of bread is owing, is not known.

(x) This is an excellent method of preserving bread fresh, and free from mould, for a long time.

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SECT. II. *Of WINE.*

177 Fruits affording wine. THERE is a considerable number of ripe fruits from which a sweet liquor may be expressed, having at the same time a certain degree of acidity. Of such fruits we have in this country the apple, the cherry, the gooseberry, the currant, &c. but by far the most valuable of these fruits is the *grape*, which grows luxuriantly in the southern parts of Europe. From grapes, fully ripe, may be expressed a liquid of a sweet taste, to which the name of *must* has been given. This liquid is composed almost entirely of five ingredients; namely, *water*, *sugar*, *jelly*, *mucilage*, and *tartarous* acid partly saturated with potass. The quantity of sugar which grapes fully ripe contain is very considerable; it may be obtained in crystals by evaporating must to the consistence of syrup, separating the tartar which precipitates during the evaporation, and then setting the must aside for some months. The crystals of sugar are gradually formed.

178 Undergo the vinous fermentation; When must is put into the temperature of about 70°, the different ingredients begin to act upon each other, and what is called *vinous fermentation* commences. The phenomena of this fermentation are an intestine motion in the liquid, its becoming thick and muddy, a temperature equal to 72.5°, and an evolution of carbonic acid gas. In a few days the fermentation ceases, the thick part subsides to the bottom, the liquid becomes clear, it has lost much of its saccharine taste, and assumed a new one, its specific gravity is diminished; and, in short, it has become the liquid well known under the name of *wine*.

Now what is the cause of this fermentation; what are the substances which mutually decompose each other; and what is the nature of the new substance formed?

These changes are produced altogether by the mutual action of the substances contained in must; for they take place equally well, and wine is formed equally well in close vessels as in the open air §.

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180 Sugar, If the juice of those fruits which contain but little sugar, as currants, be put into a favourable situation, fermentation indeed takes place, but so slowly, that the product is not *wine*, but *vinegar*: but if a sufficient quantity of sugar be added to these very juices, wine is readily produced. No substance whatever can be made to undergo vinous fermentation, and to produce wine, unless sugar be present. *Sugar* therefore is absolutely necessary for the existence of vinous fermentation; and we are certain that it is decomposed during the process; for no sugar can be obtained from properly fermented wine.

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182 And jelly are necessary. All the juices of fruits which undergo the vinous fermentation contain a quantity of jelly, or mucilage, or of both. These two substances resemble each other in so many particulars, and it is so difficult to separate them, that we shall suppose they have the same effect in the mixture. The presence of these substances renders it probable that they also are necessary for the vinous fermentation. Perhaps they act chiefly by their tendency to become acid.

Thus we see, that for the production of wine a certain temperature, a certain portion of water, sugar, a vegetable acid, and, in all probability, jelly also, is necessary. Mr Lavoisier found that sugar would not ferment unless dissolved in at least four times its weight of water. This seems to indicate that the particles of sugar must be removed to a certain distance from each other before the other ingredients can decompose them. The evolution and separation of carbonic acid gas in such quantity, shews us that the proportion of the carbon and the oxygen of the sugar is diminished. It is not certain that the mucilage of the wine is decomposed so completely as the sugar; for it has been observed, that when the must abounds in mucilage, the wine is apt to become sour.

183 Decomposition of wine. When wine is distilled by means of a low heat, there comes over a quantity of *alcohol*, and the remainder is a solution of acetous acid. From this fact, it has been concluded that wine is composed of acetous acid and alcohol. But that the distillation occasions a chemical change in the ingredients of wine is evident from this, that if we again mix the alcohol and acetous acid, we do not reproduce the wine.

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§ *Fabroni, Ann. de Chim.* xxxi. 302.

‖ *Stahl*, i.

* *Chaptal*

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THE method of making beer was known in the most remote ages; we are ignorant to whom the world is indebted for the discovery of it. Beer is usually made from *barley*.

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185 Wort, Malt, previously ground to a coarse powder, is to be infused in a sufficient quantity of pure water, of the temperature of 160°, for an hour. The infusion is then to be drawn off, and more water may be added, at a higher temperature, till all the soluble part of the malt is extracted. This infusion is known by the name of *wort*. It has a sweet taste, and contains a quantity of saccharine, and doubtless also of gelatinous matter.

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Acetous Fermentation, Putrefaction. During the fermentation, a quantity of carbonic acid gas is constantly disengaged, not in a state of purity, but containing, combined with it, a portion of the wort; and if this gas be made to pass through water, it will deposite wort, which may be fermented in the usual manner *.

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During this change, a quantity of oxygen gas is absorbed, and the whole of the spirituous part of the wine or beer disappears. Consequently its ingredients have mutually decomposed each other.

Neither pure alcohol, nor alcohol diluted with water, are capable of undergoing this change, neither do they absorb any oxygen. This absorption, then, is made by the mucilaginous matter which always exists in these liquids. No acetous acid is ever produced, unless some acid be present in the liquid. We may conclude, then, that the mucilage acquires the properties of an acid before it begins to act upon the spirituous part of the beer or the wine.

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It proceeds with most rapidity in the open air; but the contact of air is not absolutely necessary. Water is, in all cases, essential to the process, and therefore is most probably decomposed.

Putrefaction is constantly attended with a fetid odour, owing to the emission of certain gaseous matters, which differ according to the putrefying substance. Some vegetable substances, as gluten, and cruciform plants, emit ammonia; others, as onions, seem to emit phosphorated hydrogen gas. Carbonic acid gas, and hydrogen gas, impregnated with unknown vegetable matters, are almost constantly emitted in abundance. When the whole process is finished, scarcely any thing remains but the earths, the salts, and the metals, which formed a constituent part of the vegetable. But our chemical knowledge of vegetable compounds is by far too limited to enable us to follow this very complicated process with any chance of success.

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Part II. Of Animal SUBSTANCES.

Ingredients of Animals, Fibrina.

189 Classes of animals and vegetables

WHEN we compare animals and vegetables together, each in their most perfect state, nothing can be easier than to distinguish them. The plant is confined to a particular spot, and exhibits no marks of consciousness or intelligence; the animal, on the contrary, can remove at pleasure from one place to another, is possessed of consciousness, and a high degree of intelligence. But on approaching the contiguous extremities of the animal and vegetable kingdom, these striking differences gradually disappear, the objects acquire a greater degree of resemblance, and at last approach each other so nearly, that it is scarcely possible to decide whether some of those situated on the very boundary belong to the animal or vegetable kingdom.

Difficultly distinguished.

To draw a line of distinction, then, between animals and vegetables, would be a very difficult task; but it is not necessary for us, in this place at least, to attempt it; for almost the only animals whose bodies have been hitherto examined with any degree of chemical accuracy, belong to the most perfect classes, and consequently are in no danger of being confounded with plants. Indeed the greater number of facts which we have to relate, apply only to the human body, and to those of a few domestic animals. The task of analysing all animal bodies is immense, and must be the work of ages of indefatigable industry.

191 Division of this part.

We shall divide this part of the article into four chapters. In the first chapter, we shall give an account of the different ingredients hitherto found in animals, such of them at least as have been examined with any degree of accuracy: in the second, we shall treat of the different members of which animal bodies are composed; which must consist each of various combinations of the ingredients described in the first chapter: in the third, we shall treat of those animal functions which may be elucidated by chemistry: and, in the fourth, of the changes which animal bodies undergo after death.

Chap. I. Of the Ingredients of Animals.

The substances which have been hitherto detected in the animal kingdom, and of which the different parts of animals, as far as these parts have been analysed, are found to be composed, may be arranged under the following heads:

1. Fibrina,	8. Sulphur,
2. Albumen,	9. Oils,
3. Gelatine,	10. Acids,
4. Mucilage,	11. Alkalies,
5. Basis of bile,	12. Earths,
6. Urea,	13. Metals.
7. Sugar,	

These shall form the subject of the following sections:

Sect. I. *Of Fibrina.*

If a quantity of blood, newly drawn from an animal, be allowed to remain at rest for some time, a thick red clot gradually forms in it, and subsides. Separate this clot from the rest of the blood, wash it repeatedly in water till it ceases to give out any colour or taste to the liquid; the substance which remains after this process is denominated *fibrina*. It has been long known to physicians under the name of the *fibrous part of the blood*, but has not till lately been accurately described.

Albumen.

192 Fibrina how obtained.

193 Its properties.

Fibrina is of a white colour, has no taste, and is insoluble in water and in alcohol. It is soft and ductile, has a considerable degree of elasticity, and resembles very much the gluten of vegetables.

Pure fixed alkalies do not act upon it, unless they be very much concentrated, and then they decompose it. All the acids combine with it readily, and dissolve it. Water and alkalies separate it again; but it has lost entirely its former properties. With muriatic acid it forms a green coloured jelly.

When nitric acid is poured upon fibrina, azotic gas is disengaged, as Berthollet first discovered. The quantity of this gas is greater than can be obtained from the same quantity of other animal substances by the same process *. After this, prussic acid and carbonic acid gas are exhaled. By the assistance of heat the fibrina is dissolved; much nitrous gas is disengaged; the liquid, when concentrated, yields oxalic and malic acids, and white flakes are deposited, consisting of an oily substance, and of phosphat of lime †.

When fibrina is [illegible] a very large quantity of ammonia ‡.

These properties [illegible] to [illegible] that this substance is composed of [illegible] hydrogen, and carbon; but neither [illegible] nor the manner [illegible] known.

* Fourcroy, Ann. de Chim. i. 41.

† Fourcroy.

‡ Fourcroy, Ann. de Chim. i. 43.

Sect. II. Of Albumen.

194 Albumen contained in eggs.

The eggs of [illegible] contain two very different substances; a yellow [illegible] called the *yolk*; and a colourless glossy [illegible] liquid, distinguished by the name of *white*. This last is the substance which chemists have agreed to denominate *albumen* (1). The white of an egg, however, is not pure albumen. It contains, mixed with it, some carbonat of soda, and some sulphur; but the quantity of these substances is so small that they do not much influence its properties. We shall therefore consider it as *albumen*.

195 Coagulated by heat.

On the application of a heat of 165° § it *coagulates*, as is well known, into a white solid mass; the consistency of which, when other things are equal, depends, in some measure, on the time during which the heat was applied. The coagulated mass has precisely the same weight that it had while fluid.

§ Cullen.

The taste of coagulated albumen is quite different from that of liquid albumen: its appearance, too, and its

(1.) This is merely the Latin term for the white of an egg. It was first introduced into chemistry by the physiologists.

Albumen.

its properties, are entirely changed; for it is no longer soluble, as before, either in hot or in cold water.

196 Phenomena of this coagulation.

The coagulation of albumen takes place even though air be completely excluded; and even when air is present there is no absorption of it, nor does albumen in coagulating change its volume *. Acids have the property of coagulating albumen, as Scheele ascertained †. Alcohol also produces, in some measure, the same effect. *Heat*, then, *acids* and *alcohol*, are the agents which may be employed to coagulate albumen.

* *Carradori, Ann. de Chim.* xxix. 98.

† *Scheele*, ii. 58.

It is remarkable, that if albumen be diluted with a sufficient quantity of water, it can no longer be coagulated by any of these agents. Scheele mixed the white of an egg with ten times its weight of water, and then, though he even *boiled* the liquid, no coagulum appeared. Acids indeed, and alcohol, even then coagulated it; but they also lose their power, if the albumen be diluted with a much greater quantity of water, as has been ascertained by many experiments. Now we know, that when water is poured into albumen, not only a mechanical mixture takes place, but a chemical combination; for the albumen is equally distributed through every part of the liquid. Consequently its integrant particles must be farther separated from each other, and their distance must increase with the quantity of water with which they are diluted. We see, therefore, that albumen ceases to coagulate whenever its particles are separated from each other beyond a certain distance. That no other change is produced, appears evident from this circumstance, that whenever the watery solution of albumen is sufficiently concentrated by evaporation, coagulation takes place, upon the application of the proper agents, precisely as formerly.

It does not appear that the distance of the particles of albumen is changed by coagulation; for coagulated albumen occupies precisely the same sensible space as liquid albumen *.

* *Carradori.*

197 Enquiry into its cause.

Thus two things seem certain respecting the coagulation of albumen: 1. That its particles must not be beyond a certain distance; 2. That the coagulation does not produce any sensible change in their distance. To what, then, is the coagulation of albumen owing? We can conceive no change to take place from a state of liquidity to that of solidity, without some change in the figure of the particles of the body which has undergone that change: for if the figure and the distance of the particles of bodies continue the same, it is impossible to conceive any change at all to take place. Since, then, the distance of the particles of albumen does not, as far at least as we can perceive, change, we must conclude, that the figure of the particles actually does change. Now such a change may take place three ways: 1. The figure may be changed by the addition of some new molecules to each of the molecules of the body. 2. Some molecules may be abstracted from every integrant particle of the body. 3. Or the molecules, of which the integrant particles are composed, may enter into new combinations, and form new integrant particles, whose form is different from that of the old integrant particles. Some one or other of these three things must take place during the coagulation of albumen.

1. Scheele and Fourcroy have ascribed the coagulation of albumen to the first of these causes, namely, to the addition of a new substance. According to Scheele, *caloric* is the substance which is added. Fourcroy, on the contrary, affirms that it is *oxygen*.

Albumen.

Scheele supported his opinion with that wonderful ingenuity which shone so eminently in every thing which he did. He mixed together one part of white of egg and four parts of water, added a little pure alkali, and then dropt in as much muriatic acid as was sufficient to saturate the alkali. The albumen coagulated: but when he repeated the experiment, and used carbonat of alkali instead of pure alkali, no coagulation ensued. In the first case, says he, there was a double decomposition: the muriatic acid separated from a quantity of caloric with which it was combined, and united with the alkali; while, at the same instant, the caloric of the acid united with the albumen, and caused it to coagulate. The same combination could not take place when the alkaline carbonat was used, because the carbonic acid gas carried off the caloric, for which it has a strong affinity *.

*

This explanation is plausible; but it is contrary to every other known fact in chemistry, to suppose that caloric can combine with a substance without occasioning any alteration in its bulk, and cannot therefore be admitted without the most rigid proof.

Fourcroy observes, in support of his opinion, that the white of an egg is not at first capable of forming a hard coagulum, and that it only acquires that property by exposure to the atmosphere. It is well known that the white of a new laid egg is milky after boiling; and that if the shell be covered over with grease, to exclude the external air, it continues long in that state; whereas the white of an old egg, which has not been preserved in that manner, forms a very hard tough coagulum. These facts are undoubted; and they render it exceedingly probable, that albumen acquires the property of forming a hard coagulum only by absorbing oxygen: but they by no means prove that coagulation itself is owing to such an absorption. And since coagulation takes place without the presence of air, and since no air, even when it is present, is absorbed, this opinion cannot be maintained without inconsistency.

2. The only substance which can be supposed to leave albumen during coagulation, since it does not lose weight, is *caloric*. We know that in most cases where a fluid is converted into a solid, caloric is actually disengaged. It is extremely probable, then, that the same disengagement takes place here. But the opinion has not been confirmed by any proof. Fourcroy indeed says, that in an experiment made by him, the thermometer rose a great number of degrees. But as no other person has ever been able to observe any such thing, it cannot be doubted that this philosopher has been misled by some circumstance or other to which he did not attend †. It is usual, in many cases, for bodies to lose bulk when they give out caloric; but that there are exceptions to this rule, is well known.

† *Thomson's Fourc.* iii. 27

3. Even if the second opinion were true, it is scarcely possible to conceive the coagulation of albumen to take place without some change in its integrant particles. We can see how all the substances which coagulate albumen might produce such a change; and the insolubility of coagulated albumen in water, and its other different properties, render it more than probable that some such change actually takes place. But what that change is, cannot even be conjectured.

The

Gelat. The coagulation of albumen is intimately connected with one of the moſt important problems in chemiſtry, namely, the cauſe of fluidity and ſolidity. But this problem can only be reſolved, with any proſpect of ſucceſs, by a geometrical inveſtigation of the phenomena of heat.

Properties of albumen

Coagulated albumen is diſſolved by the mineral acids, greatly diluted with water; and if a concentrated acid be added to the ſolution, the albumen is again precipitated *. Alkalies, however, do not precipitate it from its ſolution in acids †. But if a ſolution of tan be poured into the acid ſolution of albumen, a very copious precipitate appears ‡.

* Scheele, ii. 57.
† Vauquelin, Ann. de Chim. xxix. 15.
‡ Ibid.

If the ſolution of tan be poured into an aqueous ſolution of uncoagulated albumen, it forms with it a very copious precipitate, which is inſoluble in water. This precipitate is a combination of tan and albumen. This property which albumen has of precipitating with tan, was diſcovered by Seguin §: it furniſhes us with a method of detecting the preſence of albumen in any liquid in which we ſuſpect it.

§ Nicholſon's Journal, i. 271

Pure alkalies and lime water alſo diſſolve albumen; at the ſame time ammonia is diſengaged, owing to the decompoſition of part of the albumen. Acids precipitate the albumen from alkalies, but its properties are changed *.

* Scheele, ii. 57.

Nitric acid, when aſſiſted by heat, diſengages azotic gas from albumen †; but the quantity is not ſo great as may be obtained from fibrina ‡. The albumen is gradually diſſolved, nitrous gas is emitted, oxalic and malic acids are formed, and a thick oily matter makes its appearance on the ſurface §. When diſtilled, it furniſhes the ſame products as fibrina, only the quantity of ammonia is not ſo great ‖.

† Scheele and Berthollet.
‡ Fourcroy, Ann. de Chim. i. 41
§ Scheele, Crell's Annals, ii. 17. Eng. Tranſl.
‖ Fourcroy, Ann. de Chim. i. 43.

Hence it follows, that albumen is compoſed of azot, hydrogen, and carbon, as well as fibrina; but the proportion of azot is not ſo great in the firſt ſubſtance as in the ſecond.

SECT. III. *Of GELATINE.*

109 Gelatine how obtained.

IF a piece of the freſh ſkin of an animal, an ox for inſtance, after the hair and every impurity is carefully ſeparated, be waſhed repeatedly in cold water, till the liquid ceaſes to be coloured, or to abſtract any thing; if the ſkin, thus purified, be put into a quantity of pure water, and boiled for ſome time, part of it will be diſſolved. Let the decoction be ſlowly evaporated till it is reduced to a ſmall quantity, and then put aſide to cool. When cold, it will be found to have aſſumed a ſolid form, and to reſemble preciſely that tremulous ſubſtance well known to every body under the name of *gelly*. This is the ſubſtance called in chemiſtry *gelatine*. If the evaporation be ſtill farther continued, by expoſing the gelly to dry air, it becomes hard, ſemitranſparent, breaks with a gloſſy fracture, and is in ſhort the ſubſtance ſo much employed in different arts under the name of *glue*. Gelatine, then, is preciſely the ſame with glue; only that it muſt be ſuppoſed always free from thoſe impurities with which glue is ſo often contaminated.

110 Its properties.

Gelatine is tranſparent and colourleſs; when thrown into water, it very ſoon ſwells, and aſſumes a gelatinous form, and gradually diſſolves completely. By evaporating the water, it may be obtained again unaltered in the form of gelly.

Animal Mucilage.

When an infuſion of tan is dropt into a ſolution of gelatine in water, there is inſtantly formed a copious white precipitate, which has all the properties of leather. This precipitate is compoſed of tan and gelatine. Theſe two ſubſtances, therefore, when combined, form leather. Albumen and gelatine are the only animal ſubſtances known which have the property of combining with tan, and forming with it an inſoluble compound. They may be always eaſily detected, therefore, by means of tan; and they may be readily diſtinguiſhed from each other, as albumen alone coagulates by heat, and gelatine alone concretes into a gelly.

Gelatine is inſoluble in alcohol, and is even precipitated from water by it; but both acids and alkalies diſſolve it. Nitric acid diſengages from it a ſmall quantity of azotic gas; diſſolves it, when aſſiſted by heat, excepting an oily matter, which appears on the ſurface of the ſolution; and converts it, partly into oxalic and malic acids *.

* Scheele, Crell's Ann. ii. 17. Eng. Tranſl.

When diſtilled, there comes over firſt water, containing ſome animal matter; the gelatine then ſwells, becomes black, emits a fetid odour, accompanied with acrid fumes: Some empyreumatic oil then comes over, and a very ſmall quantity of carbonat of ammonia: its coaly reſiduum remains behind. Theſe phenomena ſhew, that gelatine is compoſed of carbon, hydrogen, and azot; but the proportion of azot is evidently much ſmaller than in either fibrina or albumen †.

† Fourcroy, Ann. de Chim. i. 41.

SECT. IV. *Of ANIMAL MUCILAGE.*

No word in chemiſtry is uſed with leſs accuracy than *mucilage*. It ſerves as a common name for almoſt every animal ſubſtance which cannot be referred to any other claſs.

None of the ſubſtances on which the name of *animal mucilage* has been given, have been examined with care; of courſe it is unknown whether theſe ſubſtances be the ſame or different.

201 Properties of mucilage.

Whenever an animal ſubſtance poſſeſſes the following properties, it is at preſent denominated an animal mucilage by chemiſts.

1. Soluble in water.
2. Inſoluble in alcohol.
3. Neither coagulating by heat, nor concreting into a gelly by evaporation.
4. Not precipitated by the ſolution of tan.

Moſt of the ſubſtances called *mucilage* have alſo the property of abſorbing oxygen, and of becoming by that means inſoluble in water.

The mucilaginous ſubſtances ſhall be pointed out in the next chapter. In the preſent ſtate of our knowledge, any account of them here would merely be a repetition of the properties juſt mentioned.

SECT. V. *Of the BASIS of BILE.*

202 Baſis of bile how obtained.

INTO 32 parts of freſh ox bile pour one part of concentrated muriatic acid. After the mixture has ſtood for ſome hours, paſs it through a filter, in order to ſeparate a white coagulated ſubſtance. Pour the filtrated liquor, which has a fine green colour, into a glaſs veſſel, and evaporate it by a moderate heat. When it has arrived at a certain degree of concentration, a green coloured ſubſtance precipitates. Decant off the clear liquid, and waſh the precipitate in a ſmall quantity of pure

Basis of Bile.

pure water. This precipitate is the *basis of bile*, or the *resin of bile*, as it is sometimes called *.

203 Its properties

The basis of bile is of a black colour; but when spread out upon paper or on wood, it is green: its taste is intensely bitter †.

When heated to about 122°, it melts; and if the heat be still farther increased, it takes fire, and burns with rapidity. It is soluble in water, both cold and hot, and still more soluble in alcohol; but water precipitates it from that liquid ‡.

It is soluble also in alkalies, and forms with them a compound which has been compared to a soap. Acids, when sufficiently diluted, precipitate it both from water and alkalies without any change; but if they be concentrated, the precipitate is redissolved §.

When distilled, it furnishes some sebacic acid ‖.

204 Combines with oxygen.

From these properties, it is clear that the basis of bile has a considerable resemblance to oils; but it differs from them entirely in several of its properties. The addition of oxygen, with which it combines readily, alters it somewhat, and brings it still nearer to the class of oils.

In this altered state, the basis of bile may be obtained by the following process. Pour oxy-muriatic acid cautiously into bile till that liquid loses its green colour; then pass it through a filter to separate some albumen which coagulates. Pour more oxy-muriatic acid into the filtered liquid, and allow the mixture to repose for some time. The oxy-muriatic acid is gradually converted into common muriatic acid; and in the mean time the basis of bile absorbs oxygen, and acquires new properties. Pour into the liquid, after it has remained a sufficient time, a little common muriatic acid, a white precipitate immediately appears, which may be separated from the fluid. This precipitate is the basis of bile combined with oxygen.

It has the colour and the consistence of tallow, but still retains its bitter taste. It melts at the temperature of [illegible]. It dissolves readily in alcohol, and even in water, provided it be assisted by heat. Acids precipitate it from these solutions ¶.

SECT. VI. Of Urea.

205 Urea how obtained.

EVAPORATE, by a gentle heat, a quantity of human urine voided six or eight hours after a meal, till it be reduced to the consistence of a thick syrup. In this state, when put by to cool, it concretes into a crystalline mass. Pour, at different times, upon this mass four times its weight of alcohol, and apply a gentle heat; a great part of the mass will be dissolved, and there will remain only a number of saline substances. Pour the alcohol solution into a retort, and distil by the heat of a sand bath till the liquid, after boiling some time, is reduced to the consistence of a thick syrup. The whole of the alcohol is now separated, and what remains in the retort crystallizes as it cools. These crystals consist of the substance known by the name of *urea* *.

This substance was first described by Rouelle the Younger in 1773, under the name of the *saponaceous extract of urine*. He mentioned several of its properties; but very little was known concerning its nature till Fourcroy and Vauquelin published their experiments on it in 1799. These celebrated chemists have given it the name of *urea*, which we have adopted.

206 Its properties

Urea, obtained in this manner, has the form of crystalline plates crossing each other in different directions. Its colour is yellowish white; it has a fetid smell, somewhat resembling that of garlic or arsenic; its taste is strong and acrid, resembling that of ammoniacal salts; it is very viscid and difficult to cut, and has a good deal of resemblance to thick honey †. When exposed to the open air, it very soon attracts moisture, and is converted into a thick brown liquid. It is extremely soluble in water; and during its solution, a considerable degree of cold is produced ‡. Alcohol dissolves it with facility, but scarcely in so large a proportion as water. The alcohol solution yields crystals much more readily on evaporation than the solution in water.

When nitric acid is dropt into a concentrated solution of urea in water, a great number of bright pearl coloured crystals are deposited, composed of urea and nitric acid. No other acid produces this singular effect. The concentrated solution of urea in water is brown, but it becomes yellow when diluted with a large quantity of water. The infusion of nut galls gives it a yellowish brown colour, but causes no precipitate. Neither does the infusion of tan produce any precipitate ‖.

When heat is applied to urea, it very soon melts, swells up, and evaporates, with an insupportably fetid odour. When distilled, there comes over first benzoic acid, then carbonat of ammonia in crystals, some carbonated hydrogen gas, with traces of prussic acid and oil; and there remains behind a large residuum, composed of charcoal, muriat of ammonia, and muriat of soda. The distillation is accompanied with an almost insupportably fetid alliaceous odour. Two hundred and eighty-eight parts of urea yield by distillation 200 parts of carbonat of ammonia, 10 parts of carbonated hydrogen gas, 7 parts of charcoal, and 68 parts of benzoic acid, muriat of soda, and muriat of ammonia. These three last ingredients Fourcroy and Vauquelin consider as foreign substances, separated from the urine by the alcohol at the same time with the urea. Hence it follows, that 100 parts of urea, when distilled, yield 207 Its component parts.

92.027	carbonat of ammonia,
4.608	carbonated hydrogen gas,
3.225	charcoal.
99.860	

Now 200 parts of carbonat of ammonia are composed of 86 ammonia, 90 carbonic acid gas, and 24 water. Hence it follows, that 100 parts of urea are composed of

39.5	oxygen,
32.5	azot,
14.7	carbon,
13.3	hydrogen.
100.0	

But it can scarcely be doubted, that the water which was found in the carbonat of ammonia existed ready formed in the urea before the distillation ¶.

When the solution of urea in water is kept in a boiling heat, and new water is added as it evaporates, the urea is gradually decomposed, a very great quantity of carbonat of ammonia is disengaged, and at the same time acetous acid is formed, and some charcoal precipitates *.

208 Spontaneous decomposition.

When a solution of urea in water is left to itself for some time, it is gradually decomposed. A froth col-

* Cadet, Mem. Par. 1767, p. 340.

† Ibid p. 341.

‡ Fourcroy, Ann. de Chim. vii. 176.

§ Cadet and Maclurg

‖ Fourcroy.

¶ Fourcroy, Ann. de Chim. vii. 176.

* Fourcroy and Vauquelin, Ann. de Chim. xxxii. 86.

† Fourcroy and Vauquelin, Ann. de Chim. xxxii. p 87.

‡ Ibid, p. 88.

‖ Ibid.

¶ Ibid.

* Ibid, p 96.

 lects

Urea. lects on its surface; air bubbles are emitted which have a strong disagreeable smell, in which ammonia and acetous acid are distinguishable. The liquid contains a quantity of acetous acid. The decomposition is much more rapid if a little gelatine be added to the solution. In that case more ammonia is disengaged, and the proportion of acetous acid is not so great*.

209 Action of acids. When the solution of urea is mixed with one fourth of its weight of diluted sulphuric acid, no effervescence takes place; but, on the application of heat, a quantity of oil appears on the surface, which concretes upon cooling; the liquid, which comes over into the receiver, contains acetous acid, and a quantity of sulphat of ammonia remained in the retort dissolved in the undistilled mass. By repeated distillations, the whole of the urea is converted into acetous acid and ammonia †.

When nitric acid is poured upon crystallized urea, a violent effervescence takes place, the mixture frothes, assumes the form of a dark red liquid, great quantities of nitrous gas, azotic gas, and carbonic acid gas, are disengaged. When the effervescence is over, there remains only a concrete white matter, with some drops of reddish liquid. When heat is applied to this residuum, it detonates like nitrat of ammonia. Into a solution of urea, formed by its attracting moisture from the atmosphere, an equal quantity of nitric acid, of the specific gravity 1.460, diluted with twice its weight of water, was added; a gentle effervescence ensued: very gentle heat was applied, which supported the effervescence for two days. There was disengaged the first day a great quantity of azotic gas and carbonic acid gas; the second day, carbonic acid gas, and at last nitrous gas. At the same time with the nitrous gas an odour was perceivable of the oxygenated prussic acid of Berthollet. At the end of the second day, the matter in the retort, which was become thick, took fire, and burnt with a violent explosion. The residuum contained traces of prussic acid and ammonia. The receiver contained a yellowish acid liquor, on the surface of which some drops of oil swam ‡.

Muriatic acid dissolves urea, but does not alter it. Oxy-muriatic acid gas is absorbed very rapidly by a diluted solution of urea; small whitish flakes appear, which soon become brown, and adhere to the sides of the vessel like a concrete oil. After a considerable quantity of oxy-muriatic acid had been absorbed, the solution, left to itself, continued to effervesce exceeding slowly, and to emit carbonic acid and azotic gas. After this effervescence was over, the liquid contained muriat and carbonat of ammonia.

210 Of alkalies. Urea is dissolved very rapidly by a solution of potass or soda; and at the same time a quantity of ammonia is disengaged. the same substance is disengaged when urea is treated with barytes, lime, or even magnesia. Hence it is evident, that this appearance must be ascribed to the muriat of ammonia, with which it is constantly mixed. When pure solid potass is triturated with urea, heat is produced, a great quantity of ammonia is disengaged. The mixture becomes brown, and a substance is deposited, having the appearance of an empyreumatic oil. One part of urea and two of potass, dissolved in four times its weight of water, when distilled give out a great quantity of ammoniacal water; the residuum contained acetite and carbonat of potass ||.

When muriat of soda is dissolved in a solution of urea in water, it is obtained by evaporation, not in cubic crystals, its usual form, but in regular octohedrons. Muriat of ammonia, on the contrary, which crystallizes naturally in octohedrons, is converted into cubes, by dissolving and crystallizing it in the solution of urea.

Such are the properties of this singular substance, as far as they have been ascertained by the experiments of Fourcroy and Vauquelin. It differs from all animal substances hitherto examined, in the great proportion of azot which enters into its composition, and in the facility with which it is decomposed, even by the heat of boiling water.

SECT. VII. *Of Sugar.*

Sugar has been already described in the former part of this article as a vegetable substance; nothing therefore is necessary here but to point out the different states in which it is found in animals. It has never indeed been found in animals in every respect similar to the sugar of vegetables; but there are certain animal substances which have so many properties in common with sugar, that they can scarcely be arranged under any other name. These substances are,

1. Sugar of milk,
2. Honey,
3. Sugar of diabetic urine.

1. The method of obtaining sugar of milk has been already detailed in the article Chemistry, n° 488. to which we refer the reader. For an account of its properties, we are indebted to the observations of Mr Lichtenstein. 211 Sugar of milk.

When pure, it has a [illegible] taste, and no smell. Its crystals are [illegible] regular parallelopipeds [illegible] pyramids. Its specific gravity [illegible] At that temperature [illegible] its weight of water [illegible] in alcohol. When burnt, it [illegible] and exhibits precisely [illegible]. When distilled, it yields [illegible] the empyreumatic oil [illegible] acid §.

2. Honey [illegible] belongs to the [illegible] kingdom. It has a white or [illegible] consistence, a [illegible] smell; by means of alcohol, and even by water, with peculiar management, a true sugar is obtained; by distillation it affords an acid phlegm and an oil, and its coal is light and spongy like that of the mucilages of plants. Nitric acid extracts the oxalic acid, which is entirely similar to that of sugar; it is very soluble in water, with which it forms a syrup, and like sugar passes to the vinous fermentation *. 212 Honey.

3. The urine of persons labouring under the disease known to physicians by the name of *diabetes*, yields, when evaporated, a considerable quantity of matter, which possesses the properties of sugar.

SECT. VIII. *Of Oils.*

The oily substances found in animals may be arranged under three heads: 1. Fixed oils; 2. Fat; 3. Spermaceti. 213 Fixed oils.

1. The fixed oils are obtained chiefly from different kinds of fish, as the whale, &c.; and they are distinguished

* Fourcroy and Vauquelin, Ann. de Chim. xxxii. p. 96.

† Ibid. p. 104.

‡ Ibid. p. 107.

|| Ibid.

§ Scheele, ii. 70.

* Fourcroy.

Oils. guished by the name of the animal from which they are obtained, as *whale oil*, &c. These oils agree in their properties with other fixed oils; which have been already described in the article CHEMISTRY, Part II. Chap. iii. *Suppl.*

214 Properties of fat.

2. *Fat*, or rather tallow, is a well-known animal substance, much employed in the manufacture of candles and soap.

It has a white colour, often with a shade of yellow. When fresh, it has no smell, and but little taste. While cold, it is hard and brittle; but when exposed to the heat of 92°, it melts, and assumes the appearance of oil. The fat, however, which is extracted from flesh by boiling, does not melt till it reach the temperature of 127°*. Tallow and fat, in other respects, have the properties of fixed oils. They seem to be composed of a fixed oil combined with sebacic acid. When strongly heated, with contact of air, it emits a smoke of a penetrating smell, which excites tears and coughing, and takes fire when sufficiently heated to be volatilized: the charcoal it affords is not abundant. If fat be distilled on a water-bath, an insipid water, of a slight animal smell, is obtained, which is neither acid nor alkaline, but which soon acquires a putrid smell, and deposites filaments of a mucilaginous nature. This phenomenon, which takes place with the water obtained by distillation on the water-bath from any animal substance, proves, that this fluid carries up with it a mucilaginous principle, which is the cause of its alteration. Fat, distilled in a retort, affords phlegm, at first aqueous, and afterwards strongly acid; an oil, partly liquid, and partly concrete; and a very small quantity of charcoal, exceedingly difficult to incinerate; in which Crell found a small quantity of [illegible] of lime. These products have an acid and penetrating smell, as strong as that of sulphurous acid. The acid is the sebacic.

* Nicholson's Journal, i. 71.

215 Properties of spermaceti.

3. *Spermaceti* [illegible] crystalline, semitransparent [illegible] which is taken out [illegible] the cachalot; it is [illegible] of another [illegible] with which it is mixed. This [illegible] chemical properties; [illegible] some respects, and volatile oils in others.

[illegible] heated to the temperature of 133°†, it melts; and if the heat be increased, it evaporates without much alteration. When repeatedly distilled, however, it loses its solid form, and becomes like oil. When heated in contact with air, it takes fire, and burns uniformly without any disagreeable odour: hence its use in making candles.

† Ibid.

By long exposure in hot air it becomes yellow and rancid. Pure alkali combines with it, and forms a soap. Nitric and muriatic acids do not affect it, but sulphuric acid dissolves it and alters its colour.

SECT. IX. *Of Acids.*

Acids. THE acids hitherto discovered in the animal kingdom are the nine following.

1. Sulphuric,	4. Carbonic,	7. Formic,
2. Muriatic,	5. Benzoic,	8. Bombyc,
3. Phosphoric,	6. Sebacic,	9. Uric.

The first eight of these have been already described in the article CHEMISTRY, *Suppl.* it is unnecessary therefore to describe them here.

216 Discovery of uric acid.

Few persons are ignorant that concretions sometimes form in the human urinary bladder, and produce that very formidable disease known by the names of the *stone* and the *gravel*. These concretions are often extracted by a surgical operation: they are called *urinary calculi*.

The most common of these calculi is of a brown colour, and very soluble in pure potass or soda ley.

If into an alkaline solution of one of these calculi a quantity of acetous acid be poured, a copious brown coloured precipitate immediately appears, which may be separated and edulcorated in a small quantity of water. This substance is *uric acid* *.

* F[illegible] 3.

It was discovered by Scheele in 1776, and the French chemists afterwards called it *lithic acid*: but this name, in consequence chiefly of some remarks of Dr Pearson on its impropriety, has been lately given up, and that of *uric* (L) acid substituted in its place. We have adopted the new name, because we think it preferable to the old; which indeed conveyed a kind of inconsistency to those who attended to the etymological meaning of the word.

217 Its properties.

Uric acid possesses the following properties: it crystallizes in thin plates; has a brown colour, and scarcely any taste. Cold water scarcely dissolves any part of it; but it is soluble in 360 parts of boiling water. The solution reddens vegetable blues, especially the tincture of turnsol. A great part of the acid precipitates again as the water cools. It combines readily with alkalies and earths; but the compound is decomposed by every other acid. Sulphuric acid, when concentrated, decomposes it entirely *. Nitric acid dissolves it readily: the solution is of a pink colour, and has the property of tinging animal substances, the skin for instance, of the same colour †. When this solution is boiled, a quantity of azotic gas, carbonic acid gas, and of prussic acid, is disengaged ‡. Oxy-muriatic acid converts it in a few minutes into oxalic acid §.

When distilled, about a fourth of the acid passes over a little altered, and is found in the receiver crystallized in plates; a few drops of thick oil make their appearance; $\frac{1}{4}$th of the acid of concrete carbonat of ammonia, some prussiat of ammonia, some water, and carbonic acid; and there remains in the retort charcoal, amounting to about $\frac{1}{10}$th of the weight of the acid distilled ‖.

These facts are sufficient to shew us, that uric acid is composed of carbon, azot, hydrogen, and oxygen; and that the proportion of the two last ingredients is much smaller than of the other two.

The different salts which uric acid forms with alkaline and earthy bases have not been examined with attention; but urat of potass, of soda, and of lime, have been formed both by Scheele and Fourcroy; and urat of

* Scheele, i 203.

† Ibid. and Pearson.

‡ Fourcroy, Ann de Chim xxvii. 267.

§ Brugnatelli, ibid. xxxii. 184.

‖ Fourcroy, ibid xvi.

(L) From *urine*; because this acid is always found in human urine.

Alkalie, Earths, and Metals.

of ammonia is not unfrequently found cryſtallized in urinary calculi.

The order of the affinities of the different baſes for uric acids is entirely unknown; but it has been aſcertained, that its affinity for theſe baſes is much weaker than that of any other acid. Its ſalts are decompoſed even by pruſſic and carbonic acid.

Sect. X. *Of Alkalies, Earths, and Metals.*

1. All the three alkalies have been found in the animal kingdom, as we ſhall ſhew in the next chapter.

2. The only earths which have been found in animals are,

1. Lime,
2. Magneſia,
3. Silica.

The firſt in great abundance, almoſt in every large animal; the other two very rarely, and only as it were by accident.

3. The metals hitherto found in animals are,

1. Iron,
2. Manganeſe.

The firſt exiſts in all the larger animals in ſome conſiderable quantity; the ſecond has ſcarce ever been found in any quantity ſo great as to admit of being weighed.

218 Subſtances found in animals.

Such are the ſubſtances hitherto found in animals. The ſimple bodies of which all of them conſiſt are the following:

1. Azot,	6. Phoſphorus,	11. Magneſia,
2. Carbon,	7. Muriatic acid,	12. Silica,
3. Hydrogen,	8. Potaſs,	13. Iron,
4. Oxygen,	9. Soda,	14. Manganeſe.
5. Lime,	10. Sulphur,	

Of theſe, magneſia and ſilica may in a great meaſure be conſidered as foreign bodies; for they are only found in exceedingly minute quantities, and the laſt not unleſs in caſes of diſeaſe. The principal elementary ingredients are the firſt ſix: animal ſubſtances may be conſidered as in a great meaſure compoſed of them. The firſt four conſtitute almoſt entirely the ſoft parts, and the other two form the baſis of the hard parts. But we will be able to judge of this much better, after we have taken a view of the various parts of animals as they exiſt ready formed in the body. This ſhall be the ſubject of the next chapter.

Chap. II. Of the Parts of Animals.

The different ſubſtances which compoſe the bodies of animals have been deſcribed with ſufficient minuteneſs in the article Anatomy, *Encycl.* to which we beg leave to refer the reader. Any repetition in this place would be improper. Theſe ſubſtances are the following:

1. Bones and ſhells,	6. Cartilages,
2. Muſcles,	7. Skin,
3. Tendons,	8. Brain and nerves,
4. Ligaments,	9. Horns and nails,
5. Membranes,	10. Hair and feathers.

Beſides theſe ſubſtances which conſtitute the ſolid part of the bodies of animals, there are a number of fluids, the moſt important of which is the *blood*, which pervades every part of the ſyſtem in all the larger animals: The reſt are known by the name of *ſecretions*, becauſe they are formed or *ſecreted*, as the anatomiſts term it, from the blood. The principal animal ſecretions are the following:

Bones.

1. Milk,	6. Mucus of the noſe,
2. Saliva,	7. Synovia,
3. Pancreatic juice,	8. Semen,
4. Bile and biliary calculi,	9. Liquor of the amnios,
5. Tears,	10. Urine and urinary calculi.

Theſe ſubſtances ſhall form the ſubject of the following ſections.

Sect. I. *Of Bones.*

By *bones*, we mean thoſe hard, ſolid, well known ſubſtances, to which the firmneſs, ſhape, and ſtrength of animal bodies, are owing; which, in the larger animals, form, as it were, the ground-work upon which all the reſt is built. In man, in quadrupeds, and many other animals, the bones are ſituated below the other parts, and ſcarcely any of them are expoſed to view; but ſhell-fiſh and ſnails have a hard covering on the outſide of their bodies, evidently intended for defence. As theſe coverings, though known by the name of *ſhells*, are undoubtedly of a bony nature, we ſhall include them alſo in this ſection. For the very ſame reaſons, it would be improper to exclude *egg-ſhells*, and thoſe coverings of certain animals, the tortoiſe for inſtance, known by the name of *cruſts*.

It had been long known, that bones may be rendered ſoft and cartilaginous by keeping them in diluted acid ſolutions, and that ſome acids even diſſolve them altogether; that when expoſed to a violent heat, they become white, opaque, and brittle; and Dr Lewis had obſerved, that a ſudden and violent heat rendered them hard, ſemitranſparent, and ſonorous. But their component parts remained unknown till Scheele mentioned, in his diſſertation on Fluor Spar publiſhed in the Stockholm Tranſactions for 1771, that the earthy part of bones is *phoſphat of lime* (M). Since that time conſiderable additions have been made to the chemical analyſis of theſe ſubſtances by Bernard, Bouillon, and Rouelle. Mr Hatchett has publiſhed a very valuable paper on the ſubject in the Philoſophical Tranſactions for 1799; and in the 34th volume of the *Annales de Chimie*, Mr Merat-Guillot has given us a table of the component parts of the bones of a conſiderable number of animals.

The *bony parts* of animals may be divided into three claſſes; namely, *bones*, *cruſts*, and *ſhells*.

1. Bones have a conſiderable degree of hardneſs; when recent, they contain a quantity of marrow, which may be partly ſeparated from them. When the water in which bones have been for ſome time boiled is evaporated to a proper conſiſtence, it aſſumes the form of a *gelly*; bones therefore contain *gelatine*. 219 Properties of bones.

If a piece of bone be kept for ſome time in diluted muriatic, or even acetous acid, it gradually loſes a conſiderable part of its weight, becomes ſoft, and acquires 220 Their component parts.

(M) The diſcoverer of this has not been completely aſcertained: Scheele does not claim it in that paper; Bergman gives it to Gahn; but Crell affirms that it was made by Scheele.

Bones.

a certain degree of tranſparency; and, in ſhort, acquires all the properties of *cartilage*. Bone therefore conſiſts of *cartilage*, combined with ſome ſubſtance which theſe acids are capable of diſſolving and carrying off.

If pure ammonia be dropt into the acid which has reduced the bone to this ſtate, a quantity of white powder precipitates, which poſſeſſes all the properties of *phoſphat of lime*. The ſubſtance, then, which was combined with the cartilage is *phoſphat of lime*.

After the phoſphat of lime has precipitated, the addition of carbonat of ammonia occaſions a farther precipitate, which conſiſts of carbonat of lime: but the quantity of this precipitate is inconſiderable *. When concentrated acids are poured on bones, whether recent or calcined, an efferveſcence is perceptible; the gas which eſcapes renders lime water turbid, and is therefore *carbonic acid*. Now ſince bones contain carbonic acid, and ſince they contain lime alſo uncombined with any acid ſtronger than carbonic—it is evident that they contain a little *carbonat of lime*. Mr Hatchett found this ſubſtance in all the bones of quadrupeds and of fiſh which he examined †.

When bones are calcined, and the reſiduum is diſſolved in nitric acid, nitrat of barytes cauſes a ſmall precipitate, which is inſoluble in muriatic acid, and is therefore ſulphat of barytes ‡. Conſequently bones contain ſulphuric acid. It has been aſcertained, that this acid is combined with lime. The proportion of *ſulphat of lime* in bones is very inconſiderable.

Thus we have ſeen, that bones are compoſed of cartilage, which conſiſts almoſt entirely of gelatine, of phoſphat of lime, carbonat of lime, and ſulphat of lime. The following table, drawn up by Merat-Guillot ‖, exhibits a comparative view of the relative proportion of theſe ingredients in a variety of bones. The ſulphat of lime, which occurs only in a very ſmall quantity, has been confounded with phoſphat of lime.

One hundred parts contain	Gelatine.	Phoſph. of lime	Carb. of lime	Loſs.
Human bones from a burying ground,	16	67	1.5	15.5
Do. dry, but not from under the earth,	23	63	2	2
Bone of ox,	3	93	2	2
calf,	25	54	trace	21
horſe,	9	67.5	1.25	22.25
ſheep,	16	70	0.5	13.5
elk,	1.5	90	1	7.5
hog,	17	52	1	30
hare,	9	85	1	5
pullet,	6	72	1.5	20.5
pike,	12	64	1	23
carp,	6	45	0.5	48.5
Horſe tooth,	12	85.5	0.25	2.25
Ivory,	24	64	0.1	11.15
Hartſhorn,	27	57.5	1	14.5

The enamel of the teeth is compoſed of the ſame earthy ingredients as other bones; but it is totally deſtitute of cartilage *.

221 Component parts of cruſts.

2. The cruſtaceous coverings of animals, as of echini, crabs, lobſters, prawns, and cray-fiſh, and alſo the ſhells of eggs, are compoſed of the ſame ingredients as bones; but in them the proportion of carbonat of lime far exceeds that of phoſphat *.

Thus 100 parts of lobſter cruſt contain
60 carbonat of lime,
14 phoſphat,
26 cartilage,

100 †.

One hundred parts of crawfiſh cruſt contain
60 carbonat of lime,
12 phoſphat of lime,
28 cartilage.

100 ‡.

One hundred parts of hens egg-ſhells contain
89.6 carbonat of lime,
5.7 phoſphat of lime,
4.7 animal matter.

100.0 ‖.

Mr Hatchett found traces of phoſphat of lime alſo in the ſhells of ſnails.

222 Component parts of ſhells.

3. The ſhells of ſea animals may be divided into two claſſes: The firſt has the appearance of porcelain; their ſurface is enamelled, and their texture is often ſlightly fibrous. Mr Hatchett, has given them the name of *porcellaneous* ſhells. The ſecond kind of ſhell is known by the name of *mother of pearl*. It is covered with a ſtrong epidermis, and below it lies the ſhelly matter in layers *. The ſhell of the freſh water muſcle, mother of pearl, heliotis iris, and turbo olearius, are inſtances of theſe ſhells.

Porcellaneous ſhells are compoſed of carbonat of lime cemented together by a very ſmall quantity of animal matter †.

Mother of pearl ſhells are compoſed of alternate layers of carbonat of lime and a thin membranaceous or cartilaginous ſubſtance. This cartilage ſtill retains the figure of the ſhell, after all the carbonat of lime has been ſeparated by acids ‡.

Mother of pearl contains 66 carbonat of lime,
34 cartilage.

100 ‖.

Coral, which is a bony ſubſtance formed by certain ſea inſects, has a nearer relation to mother of pearl ſhells in its ſtructure than to any other bony ſubſtance, as the following table ¶ will ſhew.

	White coral.	Red coral.	Articulated coralline.
Carbonat of lime,	50	53.5	49
Animal matter,	50	46.5	51
	100	100.0	

SECT. II. *Of the* MUSCLES *of* ANIMALS.

THE muſcular parts of animals are known in common language by the name of *fleſh*. They conſtitute a conſiderable proportion of the food of man.

Muſcular fleſh is compoſed of a great number of fibres or threads, commonly of a reddiſh or whitiſh colour; but its appearance is too well known to require any deſcription. Hitherto it has not been ſubjected to any accurate chemical analyſis. Mr Thouvenel, indeed, has publiſhed a very valuable diſſertation on the ſubject;

Notes (left margin): * Hatchett, Phil. Tranſ. 1799, p. 327. † Ibid. ‡ Ibid. ‖ Ann. de Chim. xxxiv. 71. * Hatchett, Phil. Tranſ. 1799, p. 328.

Notes (right margin): * Hatchett, Phil. Tranſ. † Merat-Guillot, Ann. de Chim. xxxiv. 71. ‡ Ibid. ‖ Vauquelin, ibid. xxx. 6. * Heriſſant, Mem. Par. 1766, p. 22. Hatchett, ibid. 317. † Hatchett, ibid. ‡ Ibid. 315. ‖ Merat-Guillot, ibid. ¶ Merat-Guillot, ibid.

Muscles of Animals.

subject; but his analysis was made before the method of examining animal substances was so well understood as it is at present. It is to him, however, that we are indebted for almost all the facts known concerning the composition of muscle.

It is scarcely possible to separate the muscle from all the other substances with which it is mixed. A quantity of fat often adheres to it closely; blood pervades the whole of it; and every fibre is enveloped in a particular thin membranous matter, which anatomists distinguish by the name of *cellular substance*. The analysis of the muscle, then, cannot be supposed to exhibit an accurate view of the composition of pure muscular fibres, but only of muscular fibre not perfectly separated from other substances.

223 Analysis of muscles.

1. When a muscle is well washed in cold water, several of its parts are dissolved, and may be obtained by the usual chemical methods. When the water is evaporated slowly, it at last coagulates, and the coagulum may be separated by means of a filter. It possesses the properties of *albumen*.

2. The water is then to be evaporated gently to dryness, and alcohol poured upon the dry mass: part of it is dissolved by digestion, and there remains a saline substance, which has not been examined; but which Fourcroy conjectures to be a *phosphat*.

3. When the alcohol is evaporated to dryness, it leaves a peculiar mucous substance, soluble both in water and alcohol; and when its watery solution is very much concentrated, it assumes an acid and bitter taste. It swells upon hot coals, and melts, emitting an acid and penetrating smell. It attracts moisture from the air, and forms a saline efflorescence. In a hot atmosphere it becomes sour and putrefies. All these properties render it probable that this substance of Mr Thouvenel is that which is converted into *zoonic* acid during the roasting of meat.

4. The muscle is now to be boiled in water for some time. A quantity of fat appears on its surface in the form of oil, which may be taken off.

5. The water, when evaporated sufficiently, assumes the form of a jelly on cooling, and therefore contains a portion of *gelatine*. It contains also a little of the saline substance, and of the mucous substance mentioned above.

6. The residuum of the muscle is now white and insipid, of a fibrous structure, and insoluble in water, and has all the properties of *fibrina*.

Thus it appears that muscle is composed of

Albumen,
Mucous matter,
Gelatine,
Fibrina,
A salt.

The French chemists have discovered, that when a piece of muscle is allowed to remain a sufficient time in diluted sulphuric acid, it is converted into a substance resembling tallow: weak nitric acid, on the other hand, converts it into a substance resembling *wax* *.

* Humboldt on Galvanism, 170.

Sect. III. *Of the Soft and White Parts of Animals.*

Those parts of animals to which anatomists have given the names of cartilage, tendon, ligament, membrane, differ altogether in their appearance from the muscles. They have never been analysed. We know only that they are composed, in a great measure, of *gelatine*; for it is partly from them that *glue* is made; which does not differ from gelatine, except in not being perfectly pure.

Skin.

Mr Hatchett has ascertained that they contain no phosphat of lime as a constituent part, and scarcely any saline ingredients; for when calcined they leave but a very inconsiderable residuum. Thus 250 grains of hog's bladder left only 0.02 grain of residuum †.

† Phil. Transf. 1799. p. 333.

Sect. IV. *Of the Skin.*

The skin is that strong thick covering which envelopes the whole external surface of animals. It is composed chiefly of two parts: a thin white elastic layer on the outside, which is called *epidermis*, or *cuticle*; and a much thicker layer, composed of a great many fibres, closely interwoven, and disposed in different directions; this is called the *cutis*, or *true skin*. The *epidermis* is that part of the skin which is raised in blisters.

224 Epidermis.

1. The epidermis is easily separated from the cutis by maceration in hot water. It possesses a very great degree of elasticity.

225 Its properties.

It is totally insoluble in water and in alcohol. Pure fixed alkalies dissolve it completely, as does lime likewise, though slowly ‡. Sulphuric and muriatic acids do not dissolve it, at least they have no sensible action on it for a considerable time; but nitric acid soon deprives it of its elasticity, causes it to fall to pieces, and probably soon decomposes it §.

‡ Chaptal, Ann. de Chim. xx. 221.

It is well known that the living epidermis is tinged yellow almost instantaneously by nitric acid; but this effect does not take place, at least so speedily, when the dead cuticle is plunged in nitric acid altogether ".

§ Cruikshank on Insensible Perspiration. p. 32.

226 Cutis.

2. When a portion of cu[illegible] is macerated for some hours in water, and agitation [illegible] pressure is employed to accelerate the effect, the [illegible] and all the extraneous matter with which it was [illegible] are separated from it, but its texture remai[illegible] On evaporating the water employed, [illegible] may be obtained. No [illegible] water has any farther effect [illegible] not diminished, and its [illegible] boiled in a sufficient qua[illegible] completely dissolved, and the whole of it, by evaporating the water, obtained in the state of *gelatine* *.

* Seguin, Nicholson's Journal, i. 271.

227 Composed of gelatine.

Seguin informs us that he has ascertained, by a great variety of experiments, that the cutis differs from gelatine merely in containing an additional quantity of oxygen. Hot water (he says) expels this oxygen, and thus converts cutis into gelatine †. As these experiments have not been published, it is impossible to form any judgment of their weight.

† Ibid. 272.

228 Nature of tanning.

It is the skin or cutis of animals of which leather is formed. The process of converting skin into leather is called *tanning*. This process, though practised in the earliest ages, was merely empyrical, till the happy ingenuity of Mr Seguin led him to discover its real nature. After the epidermis and all the impurities of the skin have been separated, and its pores have been so far opened as to admit of being completely penetrated, it is steeped in an infusion of oak-bark, which consists of gallic acid and tan. The gallic acid (if we believe Seguin) deprives the skin gradually of oxygen, and thus converts it into gelatine, and the tan combines with this gelatine the instant it is formed; and this process goes

Brain and Nerves.

goes on ſo ſlowly that the texture of the ſkin is not altered. Leather, therefore, is merely a combination of gelatine and tan ‡.

‡ Nicholſon's Journal, i. 171.

Sect. V. *Of the Brain and Nerves.*

The brain and nerves are the inſtruments of ſenſation, and even of motion; for an animal loſes the power of moving a part the inſtant that the nerves which enter it are cut.

The brain and nerves have a ſtrong reſemblance to each other; and it is probable that they agree alſo in their compoſition. But hitherto no attempt has been made to analyſe the nerves. The only chemiſts who have examined the nature of *brain* are Mr Thouret * and Mr Fourcroy ‡.

* Jour. de Phyſ. xxxviii 329; Ann de Chim. xvi. 282.

The brain conſiſts of two ſubſtances, which differ from each other ſomewhat in colour, but which, in other reſpects, ſeem to be of the ſame nature. The outermoſt matter, having ſome ſmall reſemblance in colour to wood-aſhes, has been called the *cineritious* part; the innermoſt part has been called the *medullary* part.

229. Properties of brain.

Brain has a ſoft feel, not unlike that of ſoap; its texture appears to be very cloſe; its ſpecific gravity is greater than that of water.

When brain is kept in cloſe veſſels ſo that the external air is excluded, it remains for a long time unaltered. Fourcroy filled a glaſs veſſel almoſt completely with pieces of brain, and attached it to a pneumatic apparatus; a few bubbles of carbonic acid gas appeared at firſt, but it remained above a year without undergoing any farther change ‡.

‡ Ibid. 297.

This is very far from being the caſe with brain expoſed to the atmoſphere. In a few days (at the temperature of 60°) it exhales a moſt deteſtable odour, becomes acid, aſſumes a green colour, and very ſoon a great quantity of ammonia makes its appearance in it.

Cold water does not diſſolve any part of the brain; but by trituration in a mortar it forms with water a whitiſh coloured emulſion, which appears homogeneous, may be paſſed through a filter, and the brain does not precipitate by reſt. When this emulſion is heated to 145°, a white coagulum is formed. The addition of a great quantity of water alſo cauſes a coagulum to appear, which ſwims on the ſurface, but the water ſtill retains a milky colour. When ſulphuric acid is dropt into the watery emulſion of brain, white flakes ſeparate and ſwim on the ſurface, and the liquid becomes red. Nitric acid produces the ſame effects, only the liquid becomes yellow. Alcohol alſo ſeparates a white coagulum from the emulſion, after it has been mixed with it for ſome hours. When nitric acid is added to the emulſion till it becomes ſlightly acid, a coagulum is alſo ſeparated. This coagulum is of a white colour; it is inſoluble in water and in alcohol. Heat ſoftens, but does not melt it. When dried, it becomes tranſparent, and breaks with a glaſſy fracture. It has therefore ſome reſemblance to *albumen* §.

§ Ibid. 288.

When brain is triturated in a mortar with diluted ſulphuric acid, part is diſſolved, the reſt may be ſeparated, by filtration, in the form of a coagulum. The clear. The brain is completely decompoſed, a quantity of ammonia combines with the acid and forms ſulphat of ammonia, while charcoal is precipitated. The water, by evaporation and treatment with alcohol, yields ſulphats of ammonia and lime, phoſphoric acid, and phoſphats of ſoda and ammonia. Brain therefore contains

Its analyſis.

Phoſphat of lime,
———— ſoda,
———— ammonia.

Traces alſo of ſulphat of lime can be diſcovered in it. The quantity of theſe ſalts is very ſmall; altogether they do not amount to $\frac{1}{100}$th part ||.

|| Ann. de Chim. xvi. 288.

Diluted nitric acid, when triturated with brain, likewiſe diſſolves a part, and coagulates the reſt. The ſolution is tranſparent. When evaporated till the acid becomes concentrated, carbonic acid gas and nitrous gas are diſengaged; an efferveſcence takes place, white fumes appear, an immenſe quantity of ammonia is diſengaged, a bulky charcoal remains mixed with a conſiderable quantity of oxalic acid *.

* Ibid 307.

When brain is gradually evaporated to dryneſs by the heat of a water bath, a portion of tranſparent liquid ſeparates at firſt from the reſt, and the reſiduum, when nearly dry, acquires a brown colour; its weight amounts to about one-fourth of the freſh brain. It may ſtill be formed into an emulſion with water, but very ſoon ſeparates again ſpontaneouſly.

When alcohol is repeatedly boiled upon this dried reſiduum till it ceaſes to have any more action, it diſſolves about five eighths of the whole. When this alcohol cools, it depoſits a yellowiſh white ſubſtance, compoſed of brilliant plates. When kneaded together by the fingers, it aſſumes the appearance of a ductile paſte: at the temperature of boiling water it becomes ſoft, and when the heat is increaſed it blackens, exhales empyreumatic and ammoniacal fumes, and leaves behind it a charry matter †. When the alcohol is evaporated, it depoſites a yellowiſh black matter, which reddens paper tinged with turnſol, and readily diffuſes itſelf through water ‡.

† ... 310.

‡ Ibid

Pure concentrated potaſs diſſolves brain, diſengaging a great quantity of ammonia.

Theſe facts are ſufficient to ſhew us, that, excluſive of the ſmall proportion of ſaline ingredients, brain is compoſed of a peculiar matter, differing in many particulars from all other animal ſubſtances, but having a conſiderable reſemblance in many of its properties to albumen. Brain has been compared to a ſoap; but it is plain that the reſemblance is very faint, as ſcarcely any oily matter could be extricated from brain by Fourcroy, though he attempted it by all the contrivances which the preſent ſtate of chemiſtry ſuggeſted; and the alkaline proportion of it is a great deal too ſmall to merit any attention.

Sect. VI. *Of Nails, Horns, Hair, Feathers.*

These ſubſtances have not hitherto been analyſed. We know only that they have a great reſemblance to each other. They give out the ſame ſmell, and exhibit the ſame phenomena when burnt, and they yield the

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a species of soap. When muriatic acid is poured into the solution of these substances in pure soda, a quantity of sulphurated hydrogen gas is disengaged, and a black substance, doubtless charcoal, precipitates. Hence it follows that these substances contain in their composition a quantity of sulphur. Accordingly, if a bit of silver is put into the solution, it instantly assumes a black colour §.

These substances scarcely contain any earthy ingredients. One hundred grains of ox horn, after calcination, left only 0.04 grain of residuum, half of which was phosphat of lime. Seventy-eight grains of chamois horn left five grains of residuum ||.

§ Merat-Guillot, Ann. de Chim. xxxiv.

|| Hatchett, Phil. Trans. 1799, p.

Such is a very imperfect account of the solids which compose animal bodies. We proceed next to the fluid which circulates through living bodies, namely *blood*; and to the various *secretions* formed from the blood, either in order to answer some important purpose to the animal, or to be evacuated as useless, that the blood thus purified may be more proper for answering the ends for which it is destined. Many of these substances have been examined with more care by chemists than the animal solids.

Sect. VII. *Of Blood.*

Blood

Blood is a well known fluid, which circulates in the veins and arteries of the more perfect animals. It is of a red colour, has a considerable degree of consistency, and an unctuous feel, as if it contained a quantity of soap. Its taste is slightly saline, and it has a peculiar smell.

The specific gravity of human blood is, at a medium, 1.0527 *. Mr Fourcroy found the specific gravity of bullock's blood, at the temperature of 60°, to be 1.056 †. The blood does not uniformly retain the same consistence in the same animal, and its consistence in different animals is very various. It is easy to see that its specific gravity must be equally various.

* Haller's Physiology, ii. 41.

† Ann. de Chim. vii. 147.

232
Composed of red globules,

When the blood is viewed through a microscope, a great many globules, of a red colour, are seen floating in it. It is to these globules that the red colour of the blood is owing. They were first examined with attention by Leuwenhoeck. Their form, their proportion, and the changes which they undergo from the addition of various substances, have been examined with the greatest care; but hitherto without adding much to our knowledge. We neither know the ingredients of which the red globules are composed, nor the changes to which they are subjected, nor the useful purposes which they serve; nor has any accurate method been discovered of separating them from the rest of the blood, and of obtaining them in a state of purity.

When blood, after being drawn from an animal, is allowed to remain for some time at rest, it very soon coagulates into a solid mass, of the consistence of curdled milk. This mass gradually separates into two parts: one of which is fluid, and is called *serum*; the other, the coagulum, has been called *cruor*, because it alone retains the red colour which distinguishes blood. This separation is very similar to the separation of curdled milk into curds and whey. The cruor usually sinks to the bottom of the vessel, and, of course, is covered by the serum.

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The cruor, or *clot* as it is sometimes called, is of a red colour, and possesses considerable consistence. Its mean specific gravity is about 1.245 ‡. If we wash the cruor in a sufficient quantity of water, it gradually loses its red colour, and assumes the appearance of a whitish, fibrous, elastic mass, which possesses all the properties of *fibrina*. The cruor therefore is composed chiefly of fibrina. The water in which it has been washed assumes a red colour, but continues transparent. It is evident from this, that it contains, dissolved in it, the red globules; not, however, in a state of purity, for it is impossible to separate the cruor completely from the serum: consequently the water must contain both serum and red globules. We know, however, from this, that the red globules are soluble in water. The cruor of the blood, then, is composed of red globules and fibrina.

Blood

‡ Jurin, Haller's Physiolog. ii. 41.

If the cruor of the blood be exposed to a gentle heat, it becomes gradually dry and brittle. If this dry mass be submitted to distillation, it yields water, ammonia, a thick empyreumatic oil, and much carbonat of ammonia: there remains a spongy coal of a brilliant appearance, from which sulphuric acid extracts *soda* and *iron*; there remains behind a mixture of phosphat of lime and charcoal ||.

|| Fourcroy iii. 207.

When the fibrina is distilled, it yields precisely the same products; but the residuum contains neither iron nor soda. The red water, on the contrary, which had been employed to wash the cruor, contains both of these substances, especially iron; which may be obtained in the state of oxyd by evaporating this water to dryness, and calcining the residuum ¶. These facts are sufficient to demonstrate that the red globules contain iron; consequently the opinion that their colour depends upon that metal is at least possible. It is probably owing to the soda which it contains, that the presence of iron cannot be ascertained in the solution of these globules by the usual tests. The prussian alkali causes no precipitate; the infusion of nut-galls gives it no blue or purplish tinge *.

¶ Ibid.

* Wells, Phil. Trans. 1797.

234
And serum.

The serum is of a light greenish yellow colour; it has the taste, smell, and feel of the blood, but its consistence is not so great. Its mean specific gravity is about 1.0287 †. It converts syrup of violets to a green, and therefore contains an alkali. On examination, it is found that it owes this property to a portion of soda. When heated to the temperature of 156° §, the serum coagulates, as Harvey first discovered ‡. It coagulates also when boiling water is mixed with it; but if serum be mixed with six parts of cold water, it does not coagulate by heat ‡. When thus coagulated, it has a greyish white colour, and is not unlike the boiled white of an egg §. If the coagulum be cut into small pieces, a muddy fluid may be squeezed from it, which has been termed the *serosity*. After the separation of this fluid, if the residuum be carefully washed in boiling water and examined, it will be found to possess all the properties of *albumen*. The serum, therefore, contains a considerable proportion of albumen. Hence its coagulation by heat, and the other phenomena which albumen usually exhibits.

† Jurin, Haller's Physiology, ii. 41.

§ Cullen.

‡ De Gener. Anim. p. 161.

‡ Fourcroy, Ann. de Chim vii. 157.

§ Ibid. 156.

If the serosity be gently evaporated till it becomes concentrated, and then be allowed to cool, it assumes the form of a jelly, as was first observed by De Haen ||. Consequently it contains *gelatine*.

|| Ibid. 157.

If serum be mixed with twice its weight of water, and, after coagulation by heat, the albumen be separated

Blood.

ted by filtration, and the liquid be slowly evaporated till it is considerably concentrated, a number of crystals are deposited when the liquid is left standing in a cool place. These crystals consist of muriat of soda and carbonat of soda ¶.

. Thus it appears that the serum of the blood contains albumen, gelatine, soda, muriat of soda, and carbonat of soda, besides a portion of water.

¶ Fourcroy, Ann. de Chim. vii 158.

Gelatine may be precipitated from the serosity by the three mineral acids. Mr Hunter observed, that Goulard's extract, or, which is the same thing, acetite of lead dissolved in acetous acid, produces with gelatine a copious precipitate ¶. When nitric acid is distilled off serum, it converts it partly into prussic acid *. Acids, alcohol, and tan, precipitate the albumen in different states; but this, after what has been said in the last chapter, section ii. requires no farther explanation.

¶ On the Blood, 35

* Fourcroy, Ann. de Chim. vi. 180.

The proportion between the cruor and serum of the blood varies much in different animals, and even in the same animal in different circumstances. The most common proportion is about one part of cruor to three parts of serum; but in many cases the cruor exceeds and falls short of this quantity: the limits of the ratios of these substances to each other appear, from a comparison of the conclusions of most of those who have written accurately on the subject, to be 1 : 1 and 1 : 4; but the first case must be very rare indeed *.

* Haller's Physiology, ii. 47.

When new-drawn blood is stirred briskly round with a stick, or the hand, the whole of the fibrina collects together upon the stick, and in this manner may be separated altogether from the rest of the blood. The red globules, in this case, remain behind in the serum. It is in this manner that the blood is prepared for the different purposes to which it is put, as clarifying sugar, making puddings, &c. After the fibrina is thus separated, the blood no longer coagulates when allowed to remain at rest, but a spongy flaky matter separates from it and swims on the surface †.

† Fourcroy, Ann. de Chim. vii. 146.

When blood is dried by a gentle heat, water exhales from it, retaining a very small quantity of animal matter in solution, and consequently having the odour of blood. Blood dried in this manner being introduced into a retort and distilled, there comes over, first a clear watery liquor, then carbonic acid gas and carbonat of ammonia, which crystallizes in the neck of the retort; after these products there comes over a fluid oil, carbonated hydrogen gas, and an oily substance of the consistence of butter. The watery liquor possesses the property of precipitating from sulphat of iron a green powder: muriatic acid dissolves part of this powder, and there remains behind a little prussian blue. Consequently this watery liquor contains both an alkali and prussic acid ‡.

‡ Ibid. 153.

9216 grains of dried blood being put into a large crucible, and gradually heated, at first became nearly fluid, and swelled up considerably, emitted a great many fetid fumes of a yellowish colour, and at last took fire and burned with a white flame, evidently owing to the presence of oil. After the flame and the fumes had disappeared, a light smoke was emitted, which affected the eyes and the nose, which had the odour of prussic acid, and reddened moist papers stained with vegetable blues. At the end of six hours, when the matter had lost five sixths of its substance, it melted anew, exhibited a purple flame on its surface, and emitted a thick smoke. This smoke affected the eyes and nostrils, and reddened blue paper, but it had not the smell of prussic acid. When a quantity of it was collected and examined, it was found to possess the properties of phosphoric acid. The residuum amounted to 181 grains; it had a deep black colour, and a metallic brilliancy, and its particles were attracted by the magnet. It contained no uncombined soda, though the blood itself, before combustion, contains it abundantly; but water extracted from it muriat of soda, part of the rest was dissolved by muriatic acid, and, of course, was lime; there was besides a little silica, which had evidently been separated from the crucible. The iron had been reduced during the combustion ‡.

‡ Fourcroy, Ann. de Chim. vii. 151.

Such are the properties of blood, as far as they have been hitherto ascertained by experiment. We have seen that it contains the following ingredients:

235 Component parts of blood.

1. Water,	5. Iron,
2. Fibrina,	6. Soda,
3. Albumen,	7. Muriat of soda,
4. Gelatine,	8. Phosphat of lime.

But our knowledge of this singular fluid is by no means so complete as it ought to be; a more accurate analysis would probably discover the presence of other substances, and enable us to account for many of the properties of blood which at present are inexplicable.

It would be of great consequence also to compare together the blood of different animals, and of the same animal at different ages, and to ascertain in what particulars they differ from each other. This would probably throw light on some of the obscurest parts of the animal economy. Very little progress has hitherto been made in these researches: if we except the labours of Rouelle, who obtained nearly the same ingredients, though in different proportions, from the blood of a great variety of animals, the experiments of Fourcroy on the blood of the human fœtus are almost the only ones of that kind with which we are acquainted.

He found that it differs from the blood of the adult in three things: 1st, Its colouring matter is darker, and seems to be more abundant; 2d, It contains no fibrina, but probably a greater proportion of gelatine than blood of adults; 3d, It contains no phosphoric acid §.

Blood of the fœtus.

§ Ibid. 156.

The examination of diseased blood, too, would be of great consequence; because the difference of its properties from the blood of people in health might throw much light on the nature of the disease. It is well known, that when a person labours under inflammation, his blood is not susceptible of coagulating so soon as healthy blood. This longer time allows the red globules to sink to the bottom, and the coagulated fibrina appears at the top, of its natural whitish colour. Hence the appearance of the *buffy coat*, as it is called, which characterizes blood during inflammation.

237 Diseased blood.

During that disease which is known by the name of *diabetes*, in which the urine is excessive in quantity, and contains sugar, the serum of blood often, as appears from the experiments of Dr Dobson and Dr Rollo, assumes the appearance of whey; and, like it, seems to contain sugar, or, at least, it has lost its usual salt taste.

Fourcroy mentions a case of extreme feebleness, in which all the parts of the body were in an unusual relaxed state. In that patient a quantity of blood oozed out

out from the eye lids, which tinged linen blue, as if it had been stained with prussian blue. Here prussic alkali seems to have been formed in the blood.

SECT. VIII. *Of Milk.*

MILK is a fluid secreted by the female of all those animals denominated *mammalia*, and intended evidently for the nourishment of her offspring.

The milk of every animal has certain peculiarities which distinguish it from every other milk. But the animal whose milk is most made use of by man as an article of food, and with which, consequently, we are best acquainted, is the *cow*. Chemists, therefore, have made choice of cow's milk for their experiments. We shall at first confine ourselves to the properties and analysis of cow's milk, and afterwards point out in what respect the milk of other animals differs from it, as far at least as these differences have hitherto been ascertained.

238
Properties of milk.

Milk is an opaque fluid, of a white colour, a slight peculiar smell, and a pleasant sweetish taste. When newly drawn from the cow, it has a taste very different from that which it acquires after it has been kept for some hours.

It is liquid, and wets all those substances which can be moistened by water; but its consistence is greater than that of water, and it is slightly unctuous. Like water, it freezes when cooled down to about 30°; but Parmentier and Deyeux, to whom we are indebted for by far the completest account of milk hitherto published, found that its freezing point varies considerably in the milk of different cows, and even of the same cow at different times *. Milk boils also when sufficiently heated; but the same variation takes place in the boiling point of different milks, though it never deviates very far from the boiling point of water. Milk is specifically heavier than water, and lighter than blood; but the precise degree cannot be ascertained, because almost every particular milk has a specific gravity peculiar to itself.

* Jour. de Phys. xxxvii. 362.

When milk is allowed to remain for some time at rest, there collects on its surface a thick unctuous yellowish coloured substance, known by the name of *cream*. The cream appears sooner in milk in summer than in winter, evidently owing to the difference of temperature. In summer, about four days of repose are necessary before the whole of the cream collects on the surface of the liquid; but in winter it requires at least double the time †.

† Fourcroy, Ann. de Chim. vii. 167.

After the cream is separated, the milk which remains is much thinner than before, and it has a bluish white colour. If it be heated to the temperature of 100°, and a little *rennet*, which is water digested with the inner coat of a calf's stomach, and preserved with salt, be poured into it, coagulation ensues; and if the coagulum be broken, the milk very soon separates into two substances: a solid white part, known by the name of *curd*; and a fluid part, called *whey*.

Thus we see that milk may be easily separated into three parts; namely, *cream*, *curd*, and *whey*.

239
Cream

CREAM is of a yellow colour, and its consistence increases gradually by exposure to the atmosphere. In three or four days, it becomes so thick that the vessel which contains it may be inverted without risking any loss. In eight or ten days more its surface is covered over with mucors and byssi, and it has no longer the flavour of cream, but of very fat cheese *. This is the process for making what in this country is called a *cream cheese*.

Milk.

* Parmentier and Deyeux, Ann. de Chim. vii. 372.

Cream possesses many of the properties of an oil. It is specifically lighter than water, it has an unctuous feel, stains clothes precisely in the manner of oil; and if it be kept fluid, it contracts at last a taste which is very analogous to the rancidity of oils †. When kept boiling for some time, a little oil makes its appearance, and floats upon its surface ‡. Cream is neither soluble in alcohol nor oils §. These properties are sufficient to shew us that it contains a quantity of oil; but this oil is combined with a part of the curd, and mixed with some serum. Cream, then, is composed of a peculiar oil, curd, and serum. The oil may be easily obtained separate by agitating the cream for a considerable time. This process, known to every body, is called *churning*. After a certain time, the cream separates into two portions: one fluid, and resembling creamed milk; the other solid, and called *butter*.

† Ibid. 375.

‡ Ibid. 374.

§ Ibid.

240
Converted into butter.

Butter is of a yellow colour, possesses the properties of an oil, and mixes readily with other oily bodies. When heated to the temperature of 96°, it melts, and becomes transparent; if it be kept for some time melted, some curd and water or whey separate from it, and it assumes exactly the appearance of oil ||. But this process deprives it in a great measure of its peculiar flavour.

|| Fourcroy, Ann de Chim. vii. 170.

When butter is kept for a certain time, it becomes rancid, owing in a good measure to the [illegible] these foreign ingredients; for if butter be [illegible] and a great portion of these matters separ[illegible] not become rancid nearly so soon as when it is not treated in this manner. It was formerly supposed that this rancidity was owing to the developement of a peculiar acid; but Parmentier and Deyeux have shewn, that no acid is present in rancid butter *. When butter is distilled, there comes over water, sebacic acid, and oil, at first fluid, but afterwards concrete. The carbonaceous residuum is but small.

* Ibid. 379.

241
And how.

Butter may be obtained by agitating cream newly taken from milk, or even by agitating milk newly drawn from the cow. But it is usual to allow cream to remain for some time before it is churned. Now cream, by standing, acquires a sour taste; butter therefore is commonly made from sour cream. Fresh cream requires at least four times as much churning before it yields its butter as sour cream does †; consequently cream acquires, by being kept for some time, new properties, in consequence of which it is more easily converted into butter. When very sour cream is churned, every one who has paid the smallest attention must have perceived, that the butter-milk, after the churning, is not nearly so sour as the cream had been. The butter, in all cases, is perfectly sweet; consequently the acid which had been evolved has in a great measure disappeared during the process of churning. It has been ascertained, that cream may be churned, and butter obtained, though the contact of atmospheric air be excluded ‡. We have no doubt, that in all cases where such an experiment succeeded, the cream on which it was made had previously become sour. On the other hand, it has been ascertained, that when cream is churned in contact with air, it absorbs a considerable quantity of it §; and it cannot

† Fourcroy, ibid. 169.

‡ Young de Lacte, 15.

§ Mid-Lothian Report for 1795.

Milk.

cannot be doubted, that the portion absorbed is oxygen.

These facts are sufficient to afford us a key to explain what takes place during the process of churning. There is a peculiar oil in milk, which has so strong an affinity for the other ingredients, that it will not separate from them spontaneously; but it has an affinity for oxygen, and when combined with it, forms the concrete body called *butter*. Agitation produces this combination of the oil with oxygen; either by causing it to absorb oxygen from the air, or, if that be impossible, by separating it from the acid which exists in sour cream. Hence the absorption of air during churning; hence also the increase of temperature of the cream, which Dr Young found to amount constantly to 4°; and hence the sweetness of the butter-milk compared with the cream from which it was obtained.

The affinity of the oil of cream for the other ingredients is such, that it never separates completely from them. Not only is curd and whey always found in the cream, but some of this oil is constantly found in creamed milk and even in whey: for it has been ascertained by actual experiment, that butter may be obtained by churning whey; 27 Scotch pints of whey yield at an average about a pound of butter ||. This accounts for a fact well known to those who superintend dairies, that a good deal more butter may be obtained from the same quantity of milk, provided it be churned as drawn from the cow, than when the cream alone is collected and churned.

|| Mid-Lothian Report, 1795.

The butter-milk, as Parmentier and Deyeux ascertained by experiment, possesses precisely the properties of milk deprived of cream ¶.

¶ Ann. de Chim. vii. 379.

273
Properties of curd.

CURD, which may be separated from creamed milk by rennet, has all the properties of coagulated albumen. It is white and solid; and when all the moisture is squeezed out, it has a good deal of brittleness. It is insoluble in water; but pure alkalies and lime dissolve it readily, especially when assisted by heat; and when fixed alkali is used, a great quantity of ammonia is emitted during the solution. The solution of curd in soda is of a red colour, at least if heat be employed; owing probably to the separation of charcoal from the curd by the action of the alkali *. Indeed, when a strong heat has been used, charcoal precipitates as the solution cools †. The matter dissolved by the alkali may be separated from it by means of any acid; but it has lost all the properties of curd. It is of a black colour, melts like tallow by the application of heat, leaves oily stains on paper, and never acquires the consistence of curd ‡. Hence it appears that curd, by the action of a fixed alkali, is decomposed, and converted into two new substances, ammonia, and oil or rather fat.

* Ibid.

† Fourcroy, ibid. p. 175.

‡ Ibid.

Curd is soluble also in acids. If, over curd newly precipitated from milk, and not dried, there be poured eight parts of water, containing as much of any of the mineral acids as gives it a sensibly acid taste, the whole is dissolved after a little boiling §. Acetous acid and lactic acid do not dissolve curd when very much diluted ||. But these acids, when concentrated, dissolve it readily, and in considerable quantity ¶. It is remarkable enough, that concentrated vegetable acids dissolve curd readily, but have very little action on it when they are very much diluted: whereas the mineral dissolve it when much diluted; but when concentrated, have either very little effect on it, as sulphuric acid *; or decompose it, as nitric acid. By means of this last acid, as Berthollet discovered, a quantity of azotic gas may be obtained from curd.

§ Scheele, ii. 53.

|| Ibid.

¶ Parmentier and Deyeux, ibid. 417. Fourcroy, ibid. p. 173.

* Parmentier, ibid.

Curd, as is well known, is used in making *cheese*; and the cheese is the better the more it contains of cream, or of that oily matter which constitutes cream. It is well known to cheesemakers, that the goodness of it depends in a great measure on the manner of separating the whey from the curd. If the milk be much heated, the coagulum broken in pieces, and the whey forcibly separated, as is the practice in many parts of Scotland, the cheese is scarce good for any thing; but the whey is delicious, especially the last squeezed-out whey, and butter may be obtained from it in considerable quantity. A full proof that nearly the whole creamy part of the milk has been separated with the whey. Whereas if the milk be not too much heated (about 100° is sufficient), if the coagulum be allowed to remain unbroken, and the whey be separated by very slow and gentle pressure, the cheese is excellent; but the whey is almost transparent, and nearly colourless.

Of cheese.

Good cheese melts at a moderate heat; but bad cheese, when heated, dries, curls, and exhibits all the phenomena of burning horn. Hence it is evident, that all the properties in which curd differs from albumen are owing to its containing combined with it a quantity of the peculiar oil which constitutes the distinguishing characteristic of cream; hence its flavour and smell; and hence also the white colour of milk.

This sameness of curd and albumen shews us, that the coagulation of milk and of albumen depend upon the same cause. Heat, indeed, does not coagulate milk, because the albumen in it is diluted with too large a quantity of water. But if milk be boiled in contact with air, a pellicle soon forms on its surface, which has the properties of coagulated albumen: if this pellicle be removed, another succeeds; and by continuing the boiling, the whole of the albuminous or curdy matter may be separated from milk *. When this pellicle is allowed to remain, it falls at last to the bottom of the vessel, where, being exposed to a greater heat, it becomes brown, and communicates to milk that disagreeable taste which, in this country is called a *singed* taste. It happens more readily when milk is boiled along with rice, flour, &c.

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Coagulation of milk.

* Parmentier, ibid. p. 415.

If to boiling milk there be added as much of any neutral salt as it is capable of dissolving, or of sugar, or of gum arabic, the milk coagulates, and the curd separates †. Alcohol also coagulates milk ‡; as do all acids, rennet, and the infusion of the flowers of artichoke, and of the thistle ||. If milk be diluted with ten times its weight of water, it cannot be made to coagulate at all ¶.

† Scheele, ii. 52.

‡ Parmentier, ibid. p. 416.

|| Ibid.

¶ Scheele, ii. 54.

275
Properties of whey.

WHEY, after being filtered, to separate a quantity of curd which still continues to float through it, is a thin pellucid fluid, of a yellowish green colour and pleasant sweetish taste, in which the flavour of milk may be distinguished. It always contains some curd; but nearly the whole may be separated by keeping the whey for some time boiling; a thick white scum gathers on the surface, which in Scotland is known by the name of *float whey*. When this scum, which consists of the curdy part, is carefully separated, the whey, after being allowed to remain at rest for some hours, to give the remainder

Milk.

remainder of the curd time to precipitate, is decanted off, almost as colourless as water, and scarcely any of the peculiar taste of milk can be distinguished in it. If it be now slowly evaporated, it deposites at last a number of white coloured crystals, which are *sugar of milk*. Towards the end of the evaporation, some crystals of muriat of potass and of muriat of lime make their appearance *. According to Scheele, it contains also a little phosphat of lime †.

After the salts have been obtained from whey, what remains concretes into a jelly on cooling ‡. Hence it follows, that whey also contains *gelatine*. Whey, then, is composed of water, sugar of milk, gelatine, muriat of potass, and muriat of lime. The other salts, which are sometimes found in it, are only accidentally present.

If whey be allowed to remain for some time, it becomes sour, owing to the formation of a peculiar acid known by the name of *lactic acid*. It is to this property of whey that we are to ascribe the acidity which milk contracts; for neither curd nor cream, perfectly freed from serum, seem susceptible of acquiring acid properties. Hence the reason, also, that milk, after it become sour, always coagulates. Boiled milk has the property of continuing longer sweet; but it is singular enough, that it runs sooner to putrefaction than ordinary milk *.

* Parmentier, p. 417.
† Scheele, ii. 61.
‡ Rouelle.
* Parmentier, ibid. p. 343.

276
Vinegar obtained from milk.

The acid of milk differs considerably from the acetous; yet vinegar may be obtained from milk by a very simple process. If to somewhat more than 8 lbs. troy of milk, six spoonfuls of alcohol be added, and the mixture well corked be exposed to a heat sufficient to support fermentation (provided attention be paid to allow the carbonic acid gas to escape from time to time), the whey, in about a month, will be found converted into vinegar †.

† Scheele, ii. 68.

277
Milk undergoes fermentation.

Milk is almost the only animal substance which may be made to undergo the vinous fermentation, and to afford a liquor resembling wine or beer, from which alcohol may be separated by distillation. This singular fact seems to have been first discovered by the Tartars; they obtain all their spirituous liquors from mares milk. It has been ascertained, that milk is incapable of being converted into wine till it has become sour; after this, nothing is necessary but to place it in the proper temperature, the fermentation begins of its own accord, and continues till the formation of wine be completed ‡. Scheele had observed, that milk was capable of fermenting, and that a great quantity of carbonic acid gas was extricated from it during this fermentation ‖. But he did not suspect, that the result of this fermentation was the formation of an intoxicating liquor similar to wine.

‡ Parmentier, 361.
‖ Scheele, 66.

When milk is distilled by the heat of a water bath, there comes over water, having the peculiar odour of milk; which putrifies, and consequently contains, besides mere water, some of the other constituent parts of milk. After some time, the milk coagulates ¶, as always happens when hot albumen acquires a certain degree of concentration. There remains behind a thick unctuous yellowish white substance, to which Hoffman gave the name of *frangipane*. This substance, when the fire is increased, yields at first a transparent liquid, which becomes gradually more coloured; some very fluid oil comes over, then ammonia, an acid, and at last a very thick black oil. Towards the end of the process carbonated hydrogen gas is disengaged *. There remains in the retort a coal which contains carbonat of potass, muriat of potass, and phosphat of lime, and sometimes magnesia, iron, and muriat of soda †.

¶ Bouquet.
* Parmentier, ibid. p. 368.
† Mem. Med. Par. 1787. p. 607.

278
Its component parts.

Thus we see, that cows milk is composed of the following ingredients.

1. Water,	5. Sugar of milk,
2. Oil,	6. Muriat of lime,
3. Albumen,	7. Muriat of potass,
4. Gelatine,	8. Sulphur.

The milk of all other animals, as far as it has hitherto been examined, consists nearly of the same ingredients; but there is a very great difference in their portion.

279
Woman's milk.

Woman's milk has a much sweeter taste than cows milk. When allowed to remain at rest for a sufficient time, a cream gathers on its surface. This cream is more abundant than in cows milk, and its colour is usually much whiter. After it is separated, the milk is exceedingly thin, and has the appearance rather of whey, with a bluish white colour, than of creamed milk. None of the methods by which cows milk is coagulated succeed in producing the coagulation of woman's milk *. It is certain, however, that it contains curd; for if it be boiled, pellicles form on its surface, which have all the properties of curd †. Its not coagulating, therefore, must be attributed to the great quantity of water with which the curd is diluted.

* Clarke, Irish Trans. ii. 175.
† Parmentier, ibid. p. 419.

Though the cream be churned ever so long, no butter can be obtained from it; but if, after being agitated for some hours, it be allowed to remain at rest for a day or two, it separates into two parts; a fluid which occupies the inferior part of the vessel, pellucid, and colourless, like water and a thick white unctuous fluid, which swims on the surface. The lowermost fluid contains sugar of milk and some curd; the uppermost does not differ from cream except in consistence. The oily part of the cream, then, cannot be separated by agitation from the curd ‡. This cream [illegible] portion of curd than the cream of cows milk [illegible]

When this milk, after the curd is [illegible] is slowly evaporated, it yields crystals [illegible] and of muriat of soda. The quantity of sugar is rather greater than in cow's milk. According to Haller, the sugar obtained from cow's milk is to that obtained from an equal quantity of woman's milk as 35 : 58, and sometimes as 37 : 67, and in all the intermediate ratios.

Thus it appears, that woman's milk differs from that of cows in three particulars.

280
Its peculiarities.

1. It contains a much smaller quantity of curd.
2. Its oil is so intimately combined with its curd, that it does not yield butter.
3. It contains rather more sugar of milk.

Parmentier and Deyeux ascertained, that the quantity of curd in woman's milk increases in proportion to the time after delivery ‖. Nearly the same thing has been observed with respect to cow's milk.

‖ Ibid. p. 420.

281
Asses milk.

Asses milk has a very strong resemblance to human milk: it has nearly the same colour, smell, and consistence. When left at rest for a sufficient time, a cream forms upon its surface, but by no means in such abundance as in woman's milk. This cream, by very long agitation, yields a butter, which is always soft, white, and tasteless; and, what is singular, very readily mixes again with the butter-milk; but it may be again separated

Milk, Saliva

rated by agitation, while the vessel, which contains it, is plunged in cold water. Creamed asses milk is thin, and has an agreeable sweetish taste. Alcohol and acids separate from it a little curd, which has but a small degree of consistence. The serum yields sugar of milk and muriat of lime *.

* Parmentier, p. 425.

Asses milk therefore differs from cows milk in three particulars.

282 Its peculiarities.

1. Its cream is less abundant and more insipid.
2. It contains less curd.
3. It contains more sugar of milk: the proportion is 35 : 80.

283 Goats milk

GOATS MILK, if we except its consistence, which is greater, does not differ much from cows milk. Like that milk, it throws up abundance of cream, from which butter is easily obtained. The creamed milk coagulates just as cows milk, and yields a greater quantity of curd. Its whey contains sugar of milk, muriat of lime, and muriat of soda †.

† Ibid p. 425.

284 Ewes milk

EWES MILK resembles almost precisely that of the cow. Its cream is rather more abundant, and yields a butter which never acquires the consistence of butter from cows milk. Its curd has a fat and viscid appearance, and is not without difficulty made to assume the consistence of the curd of cows milk. It makes excellent cheese ‡.

‡ Ibid p. 428.

285 Mares milk

MARES MILK is thinner than that of the cow, but scarcely so thin as human milk. Its cream cannot be converted into butter by agitation. The creamed milk coagulates precisely as cows milk, but the curd is not so abundant. The serum contains sugar of milk, sulphat of lime, and muriat of lime ‖.

‖ Ibid. p. 431.

SECT. IX. *Of Saliva.*

THE fluid secreted in the mouth, which flows in considerable quantity during a repast, is known by the name of *saliva*. No accurate analysis has hitherto been made of it, though it possesses some very singular properties.

286 Properties of saliva.

It is a liquid fluid like water, but much more viscid: it has neither smell nor taste.

Its specific gravity, according to Hamberger, is 1.0167 *. When agitated, it froths like all other adhesive liquids; indeed it is usually mixed with air, and has the appearance of froth.

* Haller's Phys. vi. 52.

It neither mixes readily with water nor oil †; but by trituration in a mortar, it may be mixed so with water as to pass through a filter ‡. It has a great affinity for oxygen, absorbs it readily from the air, and gives it out again to other bodies §. Hence the reason why gold or silver, triturated with saliva in a mortar, is oxydated, as Dutenner has observed; and why the killing of mercury by oils is much facilitated by spitting into the mixture ¶. Hence also, in all probability, the reason that saliva is a useful application to sores of the skin. Dogs, and several other animals, have constantly recourse to this remedy, and with much advantage.

† Narcessus. Haller, ibid p. 54.
‡ Fordyce on Digest. p. 51.
§ Fourcroy, Ann. de Chim. xxviii. 262.
¶ Ibid.

Saliva is coagulated by oxy-muriat of mercury, by alcohol, and by nitre *. Therefore, in all probability, it contains albumen and gelatine, or some analogous substances.

* Haller's Phys. vi.

When 100 parts of saliva are distilled, there come over 80 parts of water nearly pure, then a little carbonat of ammonia, some oil, and an acid, which perhaps is the prussic. The residuum amounts to about 1.56 parts, and is composed of muriat of soda and phosphat of lime †.

The *tartar* of the teeth, which is a crust deposited from saliva, consists, as Fourcroy has ascertained, of phosphat of lime.

Tartar of

The PANCREATIC JUICE has never been examined with much attention; but it does not appear, from the experiments that have been made, to differ much from saliva.

† Nat &c. as quoted by Haller, Physio. vi. 55.

SECT. X. *Of Bile.*

BILE is a liquid of a yellowish green colour, an unctuous feel, and bitter taste, is secreted by the liver; and in most animals considerable quantities of it are usually found collected in the gall bladder.

Great attention has been paid to this liquid by physicians; because the ancients were accustomed to ascribe a very great number of diseases, and even affections of the mind, to its agency. The most accurate chemical analysis of it which has hitherto appeared is that of Mr Cadet, which was published in the Memoirs of the French Academy of Sciences for the year 1767. Several important observations had been previously made on it by Boyle, Boerhaave, Verheyen, Ramsay, and Baglivi; and some facts have since been added to our chemical knowledge of bile by Maclurg and Fourcroy. The experiments have chiefly been confined to the bile of oxen, known in this country by the name of *gall*; because it is most easily procured in large quantities.

289 Properties of bile

The specific gravity of bile seems to vary, like that of all other animal fluids. According to Hartmann, it is 1.027 *. When strongly agitated, it lathers like soap; and for this reason, as well as from a medical theory concerning its use, it has been often called an *animal soap*.

* Haller's Phys. vi. 546.

It mixes readily with water in any proportion, and assumes a yellow colour: but it refuses to unite with oil when the two fluids are agitated together; the instant that they are left at rest, the oil separates and swims on the surface †.

† Ramsay, Haller, Med. Edin. ii. 459.

When muriatic acid is poured upon bile, let it be ever so fresh, an odour of sulphurated hydrogen gas is constantly exhaled ‡. When on 100 parts of ox bile four parts of strong muriatic acid are poured, the whole instantly coagulates; but in some hours the greater part becomes again fluid; and when passed through the filter it leaves 0.26 of a white matter, which has all the properties of albumen §. This matter was detected by Ramsay; who found that it could be precipitated from bile by alcohol, acetous acid, sulphat of potass, and muriat of soda *. Cadet ascertained, that 100 parts of ox bile contain about 0.52 of albumen. It is precipitated in a state of purity by oxy-muriatic acid, provided that acid be not employed in excess †.

‡ Maclurg, p. 13.

290 Its component parts.

§ Cadet, Mem. Par. 1767. p. 312.
‖ Ibid.
* Haller, Edin. ii. 415.
† Fourcroy, Ann. de Chim. vii. 176.

The muriatic acid solution, after the separation of the albumen, has a fine grass-green colour. When concentrated by some hours evaporation in a glass cucurbit on hot coals, it deposites a very copious precipitate, and loses almost the whole of its green colour. By longer evaporation, a new precipitate, similar to the first, appears, and the remaining liquid assumes the colour of beer. This precipitate possesses all the properties of the *resin of bile*. In its moist state it amounts to 10.8 parts ‡. The same substances may be obtained from bile by nitric acid; but the resin in that

‡ Cadet, ibid.

Bile, Biliary Calculi.

case has a yellow colour, and its properties are somewhat altered *.

If 100 parts of bile be gently evaporated to dryness by a very moderate heat, the dry mass only weighs 10 parts, and has a brownish black colour. When exposed to a strong heat in a crucible, this matter swells up, takes fire, and emits very thick fumes. The residuum amounts to 1.09. By lixiviation with water, 1.87 of crystallized soda may be obtained †; consequently 100 parts of bile contain, according to Mr Kirwan's table, 0.403546 of pure soda. But it is evident that, by this method, part of the soda must have been evaporated; therefore 100 parts of bile contain more than 0.403546 of soda. Besides the soda, there is found also a small portion of muriat of soda ‡.

Cadet found the residuum, after the separation of the salts, of a black colour: it gave some traces of iron. He also obtained a calcareous salt from bile, which he considered as a sulphat; but it is more than probable that it was phosphat of lime.

Cadet also obtained from bile, by evaporating the muriatic acid solution after the separation of the resin, a salt which crystallized in trapeziums; it had a sweetish taste, and was considered by him as analogous to sugar of milk *.

* Cadet, ibid. p. 343.
† Ibid p. 350.
‡ Ibid.
* Ibid. p. 342.

Thus we see that bile contains the following ingredients:

1. Water,	5. A sweetish salt,
2. Resin,	6. Muriat of soda,
3. Albumen,	7. Phosphat of lime,
4. Soda,	8. Iron.

The proportion of these ingredients has by no means been ascertained. The presence of iron has been denied in bile, because it gives no blue precipitate with prussic alkali, and because tincture of nut-galls does not give it a black colour †. But these reasons are insufficient to overturn the experiment of Cadet, who actually found it in bile.

† Maclurg, p. 56.

When four parts of vinegar and five of bile are mixed together, the mixture has a sweet taste, and does not coagulate milk. The lactic acid has precisely the same effect as vinegar ‡.

‡ Ramsay, ibid p. 462.

When bile is distilled in a water bath, it affords a transparent watery liquor, which contracts a pretty strong odour, not unlike that of musk or amber, especially if the bile has been kept for some days before it is submitted to distillation §. The residuum is of a deep brownish green; it attracts moisture from the air, and dissolves readily in water. When distilled in a retort, it affords a watery liquor of a yellowish colour, and impregnated with alkali, oil, carbonat of ammonia, carbonic acid, and hydrogen gas. The coaly residuum is easily incinerated *. Bile, exposed to a temperature between 65° and 85°, soon loses its colour and viscidity, acquires a nauseous smell, and deposites whitish mucilaginous flakes. After the putrefaction has made considerable progress, its smell becomes sweet, and resembles amber †. If bile be heated, and slightly concentrated by evaporation, it may be kept for many months without alteration ‡.

§ Fourcroy. iii. 292.
* Ibid.
† Ibid.
‡ Vauquelin

Sect. XI. *Of Biliary Calculi.*

Hard bodies sometimes form in the gall bladder, or in the duct through which the bile passes into the intestinal canal, and stop up the passage altogether. These concretions have got the name of *biliary calculi* or *gall-stones*. As they are formed in the midst of bile, and as the substances of which they are composed must be derived from the bile, it is proper to give an account of them here, because their properties cannot fail to throw some additional light on the nature of bile itself. 291

Biliary Calculi.

Biliary calculi, all of them at least which have been hitherto examined with attention, may be divided into three classes.

Biliary calculi of three kinds.

1. The first kind comprehends those which have a white colour, and a crystallized, shining, lamellated structure.

2. The second is dark coloured, and has precisely the appearance of inspissated bile. Both these kinds are combustible.

3. The third kind comprehends those gall stones which do not flame, but gradually waste away at a red heat.

We shall take a view of each of these kinds of biliary calculi in their order. For the greater part of the chemical knowledge which has been hitherto acquired of them, the world is chiefly indebted to Mr Fourcroy. 292

Properties of the first.

1. The first species of biliary calculi was pointed out for the first time by Haller, in a dissertation published in 1749. Walther afterwards added several new facts; and at last it was accurately described by Vicq d'Azyr *. It is almost always of an oval shape, sometimes as large as a pigeon's egg, but commonly about the size of a sparrow's; and for the most part only one calculus (when of this species) is found in the gall bladder at a time. It has a white colour; and when broken, presents crystalline plates or [illegible], brilliant and white like mica, and having a soft greasy feel. Sometimes its colour is yellow or greenish; and it has constantly a nucleus of inspissated bile †.

Its specific gravity is lower than that of water. Gren found the specific gravity of one [illegible] ‡.

When exposed to a heat considerably greater than that of boiling water, this crystallized substance softens and melts; and crystallizes again when the temperature is lowered §. It is altogether insoluble in water; but hot alcohol dissolves it with facility. Alcohol, of the temperature of 167°, dissolves [illegible] of its weight of this substance; but alcohol, at the temperature of 60°, scarcely dissolves any of it *. As the alcohol cools, the matter is deposited in brilliant plates resembling talc or boracic acid †. It is soluble in oil of turpentine ‡. When melted, it has the appearance of oil, and exhales the odour of melted wax: when suddenly heated, it evaporates altogether in a thick smoke. It is soluble in pure alkalies, and the solution has all the properties of a soap. Nitric acid also dissolves it; but it is precipitated unaltered by water ‡.

† Fourcroy. Ann. de Chim. iii. 249.
‡ Ann. de Chim. v. 186.
§ Fourcroy, ibid. ii. 123.
* Ibid. p. 180.
† Ibid iii. 256.
‡ Gren, ibid. v. 187.
‡ Fourcroy, ibid. iii. 247.

This matter, which is evidently the same with the crystals which Cadet obtained from bile, and which he considered as analogous to sugar of milk, has a strong resemblance to spermaceti. Like that substance, it is of an oily nature, and inflammable; but it differs from it in a variety of particulars.

Since it is contained in bile, it is not difficult to see how it may crystallize in the gall bladder if it happens to be more abundant than usual; and the consequence must

Biliary Calculi. Tears.

must be a gall-stone of this species. Fourcroy found a quantity of the same substance in the dried human liver *.

* Fourcroy, ibid, p. 140.

293 Of the second. 2. The second species of biliary calculus is of a round or polygonal shape, of a grey colour exteriorly, and brown within. It is formed of concentric layers of a matter which seems to be inspissated bile; and there is usually a nucleus of the white crystalline matter at the centre. For the most part there are many of this species of calculus in the gall-bladder together: indeed it is frequently filled with them. Their size is usually much smaller than that of the last species.

This is the most common kind of gall stone. It may be considered as a mixture of inspissated bile, and of the crystalline matter which forms the first species: and the appearance of calculi of this kind must vary considerably, according to the proportion of these ingredients.

294 Of the third. 3. Concerning the third species of gall stone, very little is known with accuracy. Dr Saunders tells us, that he has met with some gall-stones insoluble both in alcohol and oil of turpentine; some which do not flame, but become red, and consume to an ash like a charcoal † Haller quotes several examples of similar calculi ‡.

Gall-stones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of these animals have not hitherto been examined with attention.

† On the Liver, p. 212.

‡ Physiol. vi. 567.

SECT. XII. *Of Tears.*

THAT peculiar fluid which is employed in lubricating the eye, and which is emitted in considerable quantities when we express grief by weeping, is known by the name of *tears*. For an accurate analysis of this fluid, chemistry is indebted to Messrs Fourcroy and Vauquelin. Before their dissertation, which was published in 1791, appeared, scarcely any thing was known about the nature of tears.

295 Properties of tears. The liquid called *tears* is transparent and colourless like water; it has scarcely any smell, but its taste is always perceptibly salt. Its specific gravity is somewhat greater than that of distilled water. It gives to paper, stained with the juice of the petals of mallows or violet, a permanently green colour, and therefore contains a fixed alkali *. It unites with water, whether cold or hot, in all proportions. Alkalies unite with it readily, and render it more fluid. The mineral acids produce no apparent change upon it †. Exposed to the air, this liquid gradually evaporates, and becomes thicker. When nearly reduced to a state of dryness, a number of cubic crystals form in the midst of a kind of mucilage. These crystals possess the properties of muriat of soda; only they tinge vegetable blues green, and therefore contain an excess of soda. The mucilaginous matter acquires a yellowish colour as it dries ‡.

* Fourcroy and Vauquelin, Jour. de Phys. xxxix 256.

† Ibid, p. 257.

‡ Ibid. p. 256.

This liquid boils like water, excepting that a considerable froth collects on its surface. If it be kept a sufficient time at the boiling temperature, $\frac{96}{100}$ parts of it evaporate in water; and there remain about .04 parts of a yellowish matter, which by distillation in a strong heat yield water and a little oil: the residuum consists of different saline matters §.

§ Ibid.

When alcohol is poured into this liquid, a mucilaginous matter is precipitated in the form of large white flakes. The alcohol leaves behind it, when evaporated, traces of muriat of soda and soda. The residuum which remains behind, when inspissated tears are burnt in the open air, exhibits some traces of phosphat of lime and phosphat of soda ‖.

‖ Fourcroy and Vauquelin, Jour. de Phys. p. 259.

Thus it appears that tears are composed of the following ingredients:

296 Component parts.

1. Water,
2. Mucilage,
3. Muriat of soda,
4. Soda,
5. Phosphat of lime,
6. Phosphat of soda,

The saline parts amount only to about 0.01 of the whole, or probably not so much.

The *mucilage* contained in the tears has the property of absorbing oxygen gradually from the atmosphere, and of becoming thick and viscid, and of a yellow colour. It is then insoluble in water, and remains long suspended in it without alteration. When a sufficient quantity of oxy muriatic acid is poured into tears, a yellow flaky precipitate appears absolutely similar to this inspissated mucilage The oxy-muriatic acid loses its peculiar odour; hence it is evident that it has given out oxygen to the mucilage. The property which this mucilage has of absorbing oxygen, and of acquiring new qualities, explains the changes which take place in tears which are exposed for a long time to the action of the atmosphere, as is the case in those persons who labour under a fistula lachrymalis *.

* Ibid. p. 257.

297 Mucus of the nose. The MUCUS of the nose has also been examined by Fourcroy and Vauquelin. They found it composed of precisely the same ingredients with the tears As this fluid is more exposed to the action of the air than the tears, in most cases its mucilage has undergone less or more of that change which is the consequence of the absorption of oxygen. Hence the reason of the greater viscidity and consistence of the mucus of the nose; hence also the great consistence which it acquires during colds, where the action of the atmosphere is assisted by the increased action of the parts †.

† Ibid. p. 258.

SECT. XIII. *Of Sinovia.*

WITHIN the capsular ligament of the different joints of the body, there is contained a peculiar liquid, intended evidently to lubricate the parts, and to facilitate their motion. This liquid is known among anatomists by the name of *sinovia*.

Whether it be the same in different animals, or even in all the different joints of the same animal, has not been determined; as no accurate analysis of the sinovia of different animals has been attempted. The only analysis of sinovia which has hitherto appeared is that by Mr Margueron, which was published in the 14th volume of the *Annales de Chimie*. He made use of sinovia obtained from the joints of the lower extremities of oxen.

298 Sinovia of the ox. The sinovia of the ox, when it has just flowed from the joint, is a viscid semi-transparent fluid, of a greenish white colour, and a smell not unlike frog spawn. It very soon acquires the consistence of jelly; and this happens equally whether it be kept in a cold or a hot temperature, whether it be exposed to the air or excluded from it. This consistence does not continue long; the sinovia soon recovers again its fluidity, and at the same time deposites a thready-like matter *.

* Margueron, Ann. de Chim. xiv. 124.

299 Its properties. Sinovia mixes readily with water, and imparts to that liquid a great deal of viscidity. The mixture froths when agitated; becomes milky when boiled, and

and deposites some pellicles on the sides of the dish; but its viscidity is not diminished †.

When alcohol is poured into sinovia, a white substance precipitates, which has all the properties of albumen. One hundred parts of sinovia contain 4.52 of albumen. The liquid still continues as viscid as ever; but if acetous acid be poured into it, the viscidity disappears altogether, the liquid becomes transparent, and deposites a quantity of matter in white threads, which possesses the following properties:

† Margueron, Ann. de Chim. xiv 126.

300 Its component parts

1. It has the colour, smell, taste, and elasticity of vegetable gluten.

2. It is soluble in concentrated acids and pure alkalies.

3. It is soluble in cold water, the solution frothes; acids and alcohol precipitate the fibrous matter in flakes. One hundred parts of sinovia contain 11.86 of this matter ‡.

‡ Ibid. p. 126—130.

When the liquid, after these substances have been separated from it, is concentrated by evaporation, it deposites crystals of acetite of soda. Sinovia, therefore, contains *soda*. Margueron found that 100 parts of sinovia contained about 0.71 of soda.

When strong sulphuric, muriatic, nitric, acetic, or sulphurous acid is poured into sinovia, a number of white flakes precipitate at first, but they are soon redissolved, and the viscidity of the liquid continues. When these acids are diluted with five times their weight of water, they diminish the transparency of sinovia, but not its viscidity; but when they are so much diluted that their acid taste is just perceptible, they precipitate the peculiar thready matter, and the viscidity of the sinovia disappears §.

§ Ibid. 127.

When sinovia is exposed to a dry atmosphere it gradually evaporates, and a scaly residuum remains, in which cubic crystals, and a white saline efflorescence, are apparent. The cubic crystals are muriat of soda. One hundred parts of sinovia contain about 1.75 of this salt. The saline efflorescence is carbonat of soda ||.

|| Ibid. 125.

Sinovia soon putrefies in a moist atmosphere, and during the putrefaction ammonia is exhaled. When sinovia is distilled in a retort there comes over, first water, which soon putrefies; then water containing ammonia; then empyreumatic oil and carbonat of ammonia. From the residuum muriat and carbonat of soda may be extracted by lixiviation. The coal contains some phosphat of lime ¶.

¶ Ibid. 128.

From the analysis of Mr Margueron it appears that sinovia is composed of the following ingredients:

11.86	fibrous matter,
4.52	albumen,
1.75	muriat of soda,
.71	soda,
.70	phosphat of lime (N),
80.57	water,
100.00.	

SECT. XIV. *Of Semen.*

THE peculiar liquid secreted in the testes of males, and destined for the impregnation of females, is known by the name of *semen*. The human semen alone has hitherto been subjected to chemical analysis. Nothing is known concerning the seminal fluid of other animals. Vauquelin published an analysis of the human semen in 1791.

Semen.

301 Properties of semen.

Semen, when newly ejected, is evidently a mixture of two different substances: the one, fluid and milky, which is supposed to be secreted by the prostate gland; the other, which is considered as the true secretion of the testes, is a thick mucilaginous substance, in which numerous white shining filaments may be discovered *. It has a slight disagreeable odour, an acrid irritating taste, and its specific gravity is greater than that of water. When rubbed in a mortar it becomes frothy, and of the consistence of pomatum, in consequence of its enveloping a great number of air bubbles. It converts paper stained with the blossoms of mallows or violets to a green colour, and consequently contains an alkali †.

* Vauquelin, Ann. de Chim. ix. 64.

† Ibid. p. 63.

As the liquid cools, the mucilaginous part becomes transparent, and acquires greater consistency; but in about twenty minutes after its emission, the whole becomes perfectly liquid. This liquefaction is not owing to the absorption of moisture from the air, for it loses instead of acquiring weight during its exposure to the atmosphere; nor is it owing to the action of the air, for it takes place equally in close vessels ‡.

‡ Ibid. p. 66.

Semen is insoluble in water before this spontaneous liquefaction, but afterwards it dissolves readily in it. When alcohol or oxy-muriatic acid is poured into this solution, a number of white flakes are precipitated §. Concentrated alkalies facilitate its combination with water. Acids readily dissolve the semen, and the solution is not decomposed by alkalies; neither indeed is the alkaline solution decomposed by acids ||.

§ Ibid. p. 70.

|| Ibid. p. 71.

Lime disengages no ammonia from fresh semen; but after that fluid has remained for some time in a moist and warm atmosphere, lime separates a great quantity from it. Consequently ammonia is formed during the exposure of semen to air ¶.

¶ Ibid. p.

302 Its component parts.

When oxy-muriatic acid is poured into semen, a number of white flakes precipitate, and the acid loses its peculiar odour. These flakes are insoluble in water, and even in acids. If the quantity of acid be sufficient, the semen acquires a yellow colour. Thus it appears that semen contains a mucilaginous substance, analogous to that of the tears, which coagulates by absorbing oxygen. Mr Vauquelin obtained from 100 parts of semen six parts of this mucilage.

When semen is exposed to the air about the temperature of 60°, it becomes gradually covered with a transparent pellicle, and in three or four days deposites small transparent crystals, often crossing each other in such a manner as to represent the spokes of a wheel. These crystals, when viewed through a microscope, appear to be four-sided prisms, terminated by very long four sided pyramids. They may be separated by diluting the liquid with water, and decanting it off. They have all the properties of phosphat of lime *. If, after the appearance of these crystals, the semen be still allowed to remain exposed to the atmosphere, the pellicle on

* Ibid. p. 67 and 73.

(N) Mr Hatchett found only 0.208 of phosphat of lime in the sinovia which he examined. He found, however, traces of some other phosphat; probably phosphat of soda. *Phil. Trans.* 1799, p. 246.

on its surface gradually thickens, and a number of white round bodies appear on different parts of it. These bodies also are phosphat of lime, prevented from crystallizing regularly by the too rapid abstraction of moisture. Mr Vauquelin found that 100 parts of semen contain three parts of phosphat of lime †. If at this period of the evaporation the air becomes moist, other crystals appear in the semen, which have the properties of carbonat of soda. The evaporation does not go on to complete exsiccation, unless at the temperature of 77°, and when the air is very dry. When all the moisture is evaporated, the semen has lost 0.9 of its weight, the residuum is semi transparent like horn, and brittle ‡.

† Vauquelin, Ann. de Chim. p 68.

‡ Ibid.

When semen is kept in very moist air, at the temperature of about 77°, it acquires a yellow colour, like that of the yolk of an egg; its taste becomes acid, it exhales the odour of putrid fish, and its surface is covered with abundance of the byssus septica §.

§ Ibid.

When dried semen is exposed to heat in a crucible, it melts, acquires a brown colour, and exhales a yellow fume, having the odour of burnt horn. When the heat is raised, the matter swells, becomes black, and gives out a strong odour of ammonia. When the odour of ammonia disappears, if the matter be lixiviated with water, an alkaline solution may be obtained, which, by evaporation, yields crystals of carbonat of soda. Mr Vauquelin found that 100 parts of semen contain one part of soda ¶. If the residuum be incinerated, there will remain only a quantity of white ashes, consisting of phosphat of lime.

¶ Ibid. p. 75.

Thus it appears that semen is composed of the following ingredients:

90 water,
6 mucilage,
3 phosphat of lime,
1 soda,

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100

Sect. XV. Liquor of the Amnios.

The fœtus in the uterus is enveloped in a peculiar membranous covering, to which anatomists have given the name of *amnios*. Within this amnios there is a liquid, distinguished by the name of the *liquor of the amnios*, which surrounds the fœtus on every part. This liquid, as might have been expected, is very different in different animals, at least the liquor amnii in women and in cows, which alone have hitherto been analysed, have not the smallest resemblance to each other. These two liquids have been lately analysed by Vauquelin and Buniva, and the result of their analysis has been published in the 33d volume of the *Annales de Chimie*.

303 Liquor of the human amnios.

1. The liquor of the amnios of women is a fluid of a slightly milky colour, a weak but pleasant odour, and a saltish taste. The white colour is owing to a curdy matter suspended in it, for it may be obtained quite transparent by filtration *.

* Ann. de Chim. xxxiii. 270.

Its specific gravity is 1.005. It gives a green colour to the tincture of violets, and yet it reddens very decidedly the tincture of turnsol. These two properties would indicate at once the presence of an acid and of an alkali. It froths considerably when agitated. On the application of heat it becomes opaque, and has then a great resemblance to milk diluted with a large quantity of water. At the same time it exhales the odour of boiled white of egg †.

Liquor of the Amnios.

Acids render it more transparent. Alkalies precipitate an animal matter in small flakes. Alcohol likewise produces a flaky precipitate, which, when collected and dried, becomes transparent, and very like glue. The infusion of nut galls produces a very copious brown coloured precipitate. Nitrat of silver occasions a white precipitate, which is insoluble in nitric acid, and consequently is muriat of silver †.

† Ann. de Chim. xxxiii. 271.

† Ibid.

When slowly evaporated it becomes slightly milky, a transparent pellicle forms on its surface, and it leaves a residuum which does not exceed 0.012 of the whole. By lixiviating this residuum, and evaporating the ley, crystals of muriat and carbonat of soda, may be obtained. The remainder, when incinerated, exhales a fetid and ammoniacal odour, resembling that of burning horn; the ashes consist of a small quantity of carbonat of soda, and of phosphat and carbonat of lime ‡.

‡ Ibid. p. 272.

Thus we see that the liquor of the human amnios is composed of about

98.8 water,
1.2 { albumen, muriat of soda, soda, phosphat of lime, lime,

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100.0

304 Curdy matter deposited on the fœtus.

While the fœtus is in the uterus, a curdy-like matter is deposited on the surface of its skin, and in particular parts of its body. This matter is often found collected in considerable quantities. It is evidently deposited from the liquor of the amnios; and consequently the knowledge of its peculiar nature must throw considerable light upon the properties and use of that liquor. For an analysis of this substance we are also indebted to Vauquelin and Buniva.

Its colour is white and brilliant; it has a soft feel, and very much resembles newly prepared soap. It is insoluble in water, alcohol, and oils. Pure alkalies dissolve part of it, and form with it a kind of soap. On burning coals it decrepitates like a salt, becomes dry and black, exhales vapours which have the odour of empyreumatic oil, and leaves a residuum which is very difficultly reduced to ashes. When heated in a platinum crucible it decrepitates, lets an oil exude, curls up like horn, and leaves a residuum, consisting chiefly of carbonat of lime ‡.

‡ Ibid. p. 274.

These properties shew that this matter is different from every one of the component parts of the liquor of the amnios, and that it has a great resemblance to the *fat*. It is probable, as Vauquelin and Buniva have conjectured, that it is formed from the albumen of that liquid; which has undergone some unknown changes. It has been long known, that the parts of a fœtus which has lain for some time after it has been deprived of life in the uterus, are sometimes converted into a kind of fatty matter. It is evident that this substance, after it is deposited upon the skin of the fœtus, must preserve it in a great measure from being acted upon by the liquor of the amnios.

305 Liquor of the amnios of the cow.

2. The liquor of the amnios of the cow has a viscidity similar to mucilage of gum arabic, a brownish red colour, an acid and bitter taste, and a peculiar odour, not unlike that of some vegetable extracts. Its specific gravity is 1.028. It reddens the tincture of turnsol, and

Liquor of the Am- and therefore contains an acid. Muriat of barytes causes a very abundant precipitate, which renders it probable that it contains sulphuric acid. Alcohol separates from it a great quantity of a reddish coloured matter §.

§ Ann de Chim xxxiii. p. 275.

306 Its component parts. When this liquid is evaporated, a thick frothy scum gathers on the surface, which is easily separated, and in which some white acid-tasted crystals may be discovered. By continuing the evaporation, the matter becomes thick, and viscid, and has very much the look of honey. Alcohol boiled upon this thick matter, and filtered off, deposites upon cooling brilliant needle-formed crystals nearly an inch in length. These crystals may be obtained in abundance by evaporating the liquor of the amnios to a fourth part of its bulk, and then allowing it to cool. The crystals soon make their appearance. They may be separated and purified by washing them in a small quantity of cold water. These crystals have the properties of an acid §.

§ Ibid p. 276.

If after the separation of this acid the liquor of the amnios be evaporated to the consistence of a syrup, large transparent crystals appear in it, which have all the properties of sulphat of soda. The liquid of the amnios of cows contains a considerable quantity of this salt.

Thus it appears that the liquor of the amnios of cows contains the following ingredients:

1. Water,
2. A peculiar animal matter,
3. A peculiar acid,
4. Sulphat of soda.

307 Nature of the animal matter. The animal matter possesses the following properties: It has a reddish brown colour, and a peculiar taste; it is very soluble in water, but insoluble in alcohol, which has the property of separating it from water. When exposed to a strong heat it swells, exhales first the odour of burning gum, then of empyreumatic oil and of ammonia, and at last the peculiar odour of prussic acid becomes very conspicuous. It differs from gelatine in the viscidity which it communicates to water, in not forming a jelly when concentrated, and in not being precipitated by tan. It must be therefore ranked among the very undefined and inaccurate class of *animal mucilages*.

When burnt, it leaves a very large coal, which is readily incinerated, and leaves a little white ashes, composed of phosphat of magnesia, and a very small proportion of phosphat of lime ||.

|| Ibid. p. 278.

308 Amniotic acid. The acid substance is of a white and brilliant colour; its taste has a very slight degree of sourness; it reddens the tincture of turnsol; it is scarcely soluble in cold water, but very readily in hot water, from which it separates in long needles as the solution cools. It is soluble also in alcohol, especially when assisted by heat. It combines readily with pure alkalies, and forms a substance which is very soluble in water. The other acids decompose this compound; and the acid of the liquor of the amnios is precipitated in a white crystalline powder. This acid does not decompose the alkaline carbonats at the temperature of the atmosphere, but it does so when assisted by heat. It does not alter solutions of silver, lead, or mercury, in nitric acid. When exposed to a strong heat, it frothes and exhales an odour of ammonia and of prussic acid. The properties are sufficient to shew that it is different from every other acid. Vauquelin and Boniva have given it the name of *amniotic acid*. It approaches nearest to the saccholactic and the *uric* acids; but the sachlactic acid does not furnish ammonia by distillation like the amniotic. The uric acid is not so soluble in hot water as the amniotic, it does not crystallize in white brilliant needles, and it is insoluble in boiling alcohol; in both which respects it differs completely from amniotic acid *.

Urine.

* Ann. de Chim. xxxiii. p. 279.

Sect. XVI. Of Urine.

309 Urine. No animal substance has attracted more attention than urine, both on account of its supposed connection with various diseases, and on account of the very singular products which have been obtained from it. Mr Boyle, and the other chemists who were his contemporaries, were induced to attend particularly to this liquid, by the discovery of a method of obtaining phosphorus from it. Boerhaave, Haller, Haupt, Margraf, Pott, Rouelle, Proust, and Klaproth, successively, improved the method of obtaining the phosphoric salts from urine, or added something to our knowledge of the component parts of these salts. Scheele added greatly to our knowledge of urine by detecting several new substances in it which had not been suspected. Cruickshank has given us a very valuable paper on urine in the second edition of *Rollo's Diabetes*; and Fourcroy and Vauquelin have lately published the most complete analysis of it which has hitherto appeared.

Fresh urine is a liquid of a peculiar aromatic odour, an orange colour, of greater or less intensity, and an acid saline taste.

Its specific gravity varies from 1.005 to 1.033 *.

1. It reddens paper stained with turnsol and with the juice of radishes, and therefore contains an acid.

2. If a solution of ammonia be poured into fresh urine, a white powder precipitates, which has the properties of phosphat of lime. The presence of this substance in urine was first discovered by Scheele †. If lime water be poured into urine, phosphat of lime precipitates in greater abundance than when ammonia is used; consequently the acid which urine contains is the phosphoric. Thus we see that the phosphat of lime is kept dissolved in urine by an excess of acid. This also was first discovered by Scheele ‡. This substance is most abundant in the urine of the sick. Berthollet has observed, that the urine of gouty people is less acid than that of people in perfect health. The average quantity of phosphat of lime in healthy urine is, as Cruickshank has ascertained, about $\frac{1}{300}$ of the weight of the urine §.

* ... 40.

Contains phosphat of lime.

† Scheele, i. 208.

‡ Ibid.

§ Phil. Mag. ii. 241.

311 Phosphat of magnesia. 3. If the phosphat of lime precipitated from urine be examined, a little magnesia will be found mixed with it. Fourcroy and Vauquelin have ascertained that this is owing to a little phosphat of magnesia which urine contains, and which is decomposed by the alkali or lime employed to precipitate the phosphat of lime ¶.

¶ Ann. de Chim. xxxi. 66.

312 Uric acid. 4. When fresh urine cools, it often lets fall a brick coloured precipitate, which Scheele first ascertained to be crystals of uric acid. All urine contains this acid, even when no sensible precipitate appears when it cools. For if a sufficient quantity of clear and fresh urine be evaporated to $\frac{1}{128}$ of its weight, a subtle powder precipitates to the bottom, and attaches itself in part very firmly to the vessel. This part may be dissolved in pure alkali, and precipitated again by acetous acid. It exhibits all the properties of uric acid *. The quantity of uric acid in urine is very various. During intermittent

* Scheele, i. 207.

Urine.

termittent fevers it is depofited very copioufly, and has been long known to phyficians under the name of *lateritious fediment*. This fediment always makes its appearance at the crifis of fevers. In gouty people, the fame fediment appears in equal abundance towards the end of a paroxyfm of the difeafe (P). And if this fediment fuddenly difappears after it has begun to be depofited, a frefh attack may be expected *.

* *Cruikfhank, Phil. Mag.* ii. 249.

5. If frefh urine be evaporated to the confiftence of a fyrup, and muriatic acid be then poured into it, a precipitate appears which poffeffes the properties of

313 Benzoic acid,

benzoic acid. Scheele firft difcovered the prefence of benzoic acid in urine. He evaporated it to drynefs, feparated the faline part, and applied heat to the refiduum. The benzoic acid was fublimed, and found cryftallized in the receiver. The method which we have given is much eafier; it was firft propofed by Fourcroy and Vanquelin †. By it very confiderable quantities of benzoic acid may be obtained from the urine of horfes and cows, where it is much more abundant than in human urine. In human urine it varies from $\frac{1}{1400}$ to $\frac{1}{1800}$ of the whole §.

† *Ann. de Chim.* xxxi. 62.

§ *Ibid.* p. 63.

314 Albumen and gelatine,

6. When an infufion of tan is dropt into urine, a white precipitate appears, having the properties of the combination of tan and albumen, or gelatine. Urine, therefore, contains albumen and gelatine. Thefe fubftances had been fufpected to be in urine, but their prefence was firft demonftrated by Seguin, who difcovered the above method of detecting them. Their quantity in healthy urine is very fmall. Cruikfhank found that the precipitate afforded by tan in healthy urine amounted to $\frac{1}{240}$th part of the weight of the urine ‡. It is to thefe fubftances that the appearance of the *cloud*, as it is called, or the mucilaginous matter, which is fometimes depofited as the urine cools, is owing. It is probable that healthy urine contains only gelatine and not albumen, though the quantity is too fmall to admit of accurate examination; but in many difeafes the quantity of thefe matters is very much increafed. The urine of dropfical people often contains fo much albumen, that it coagulates not only on the addition of acids, but even on the application of heat §. In all cafes of impaired digeftion, the albuminous and gelatinous part of urine is much increafed. This forms one of the moft confpicuous and important diftinctions between the urine of thofe who enjoy good and bad health ||.

‡ *Phil. Mag.* ii. 243.

|| *Fourcroy and Vauquelin, Ann. Chim.* xi. 81

315 Urea,

7. If urine be evaporated by a flow fire to the confiftence of a thick fyrup, it affumes a deep brown colour, and exhales a fetid ammoniacal odour. When allowed to cool, it concretes into a mafs of cryftals, compofed of all the component parts of urine. If four times its weight of alcohol be poured upon this mafs, at intervals, and a flight heat be applied, the greateft part of it is diffolved. The alcohol, which has acquired a brown colour, is to be decanted off, and diftilled in a crucible in a fand heat, till the mixture has boiled for fome time, and acquired the confiftence of a fyrup. By this time the whole of the alcohol has paffed off, and the matter, on cooling, cryftallizes in quadrangular plates which interfect each other. This fubftance is *urea*, which compofes $\frac{4}{5}$ of the urine, provided the watery part be excluded. To this fubftance the tafte, fmell, and colour of urine are owing. It is a fubftance which characterizes urine, and conftitutes it what it is, and to which the greater part of the very fingular phenomena of urine are to be afcribed.

The colour of urine depends upon the urea; the greater the quantity, the deeper is the colour. It may be detected by evaporating urine to the confiftence of a fyrup, and pouring into it concentrated nitric acid. Immediately a great number of white fhining cryftals appear in the form of plates, very much refembling cryftallized boracic acid. Thefe cryftals are urea combined with nitric acid.

The quantity of urea varies exceedingly in different urines. In the urine voided foon after a meal, very little of it is to be found, and fcarcely any at all in that which hyfterical patients void during a paroxyfm.

8. If urine be flowly evaporated to the confiftence of 316 Muriat of foda,
a fyrup, a number of cryftals make their appearance in it. Two of thefe are remarkable by their form: one of them confifts of fmall regular octahedrons; which, when examined, are found to poffefs the properties of muriat of foda. Urine, therefore, contains muriat of foda. It is well known that muriat of foda cryftallizes in cubes; the fingular modification of its form in urine is owing to the action of urea. It has been long known that urine faturated with muriat of foda depofites that falt in regular octahedrons.

9. Another of the falts which appear during the evaporation of urine has the form of regular cubes. This 317 Muriat of ammonia,
falt has the properties of muriat of ammonia. Now the ufual form of the cryftals of muriat of ammonia is the octahedron. The change of its form in urine is produced alfo by urea.

10. The faline refiduum which remains after the feparation of urea from cryftallized urine by means of alcohol, has been long known under the names of fufible 318 Phofphat of ammonia and of foda
falt of urine and microcofmic falt. Various methods of obtaining it have been given by chemifts from Boerhaave, who firft publifhed a procefs, to Rouelle and Chaulnes, who gave the method juft mentioned. If this faline mafs be diffolved in a fufficient quantity of hot water, and allowed to cryftallize fpontaneoufly in a clofe veffel, two fets of cryftals are gradually depofited. The lowermoft fet has the figure of flat rhomboidal prifms; the uppermoft, on the contrary, has the form of rectangular tables. Thefe two may be eafily feparated by expofing them for fome time to a dry atmofphere. The rectangular tables efflorefce and fall to powder, but the rhomboidal prifms remain unaltered.

When thefe falts are examined, they are found to have the properties of phofphats. The rhomboidal prifms confift of phofphat of ammonia united to a little phofphat of foda; the rectangular tables, on the contrary,

(P) The concretions which fometimes make their appearance in gouty joints have been found to confift chiefly of uric acid. This fingular coincidence deferves the attention of phyfiologifts: it cannot fail, fooner or later, to throw light, not only upon gout, but upon fome of the animal functions.

trary, are phosphat of soda united to a small quantity of phosphat of ammonia. Urine, then, contains phosphat of soda and phosphat of ammonia.

Thus we have found that urine contains the twelve following substances:

Water,	7. Gelatine and albumen,
Phosphoric acid,	8. Urea,
Phosphat of lime,	9. Muriat of soda,
Phosphat of magnesia,	10. Muriat of ammonia,
Uric acid,	11. Phosphat of soda,
Benzoic acid,	12. Phosphat of ammonia.

319 Sometimes other salts.

These are the only substances which are constantly found in healthy urine *; but it contains also occasionally other substances. Very often muriat of potass may be distinguished among the crystals which form during its evaporation. The presence of this salt may always be detected by dropping cautiously some tartarous acid into urine. If it contains muriat of potass, there will precipitate a little tartar, which may easily be recognised by its properties *.

* Fourcroy and Vauquelin, Ann de Chim xxxi. 69.

* Cruikshank, Phil. Mag. ii, 441.

Urine sometimes also contains sulphat of soda, and even sulphat of lime. The presence of these salts may be ascertained by pouring into urine a solution of muriat of barytes, a copious white precipitate appears, consisting of the barytes combined with phosphoric acid, and with sulphuric acid, if any be present. This precipitate must be treated with a sufficient quantity of muriatic acid. The phosphat of barytes is dissolved, but the sulphat of barytes remains unaltered †.

† Fourcroy, Ann. de Chim vii. 183.

320 Putrefaction of urine.

No substance putrefies sooner, or exhales a more detestable odour during its spontaneous decomposition, than urine; but there is a very great difference in this respect in different urines. In some, putrefaction takes place almost instantaneously as soon as it is voided; in others, scarcely any change appears for a number of days. Fourcroy and Vauquelin have ascertained that this difference depends on the quantity of gelatine and albumen which urine contains. When there is very little of these substances present, urine remains long unchanged; on the contrary, the greater the quantity of gelatine or albumen, the sooner does putrefaction commence. The putrefaction of urine, therefore, is, in some degree, the test of the health of the person who has voided it; for a superabundance of gelatine in urine always indicates some defect in the power of digestion *.

* Ann de Chim. xxxi. 61.

The rapid putrefaction of urine, then, is owing to the action of gelatine on urea. We have seen already the facility with which that singular substance is decomposed, and that the new products into which it is changed are, ammonia, carbonic acid, and acetous acid. Accordingly, the putrefaction of urine is announced by an ammoniacal smell. Mucilaginous flakes are deposited, consisting of part of the gelatinous matter. The phosphoric acid is saturated with ammonia, and the phosphat of lime, in consequence, is precipitated. Ammonia combines with the phosphat of magnesia, forms with it a triple salt, which crystallizes upon the sides of the vessel in the form of white crystals, composed of six-sided prisms, terminated by six sided pyramids. The uric and benzoic acids are saturated with ammonia; the acetous acid, and the carbonic acid, which are the products of the decomposition of the urea, are also saturated with ammonia, and notwithstanding the quantity which exhales, the production of this substance is so abundant, that there is a quantity of unsaturated alkali in the liquid. Putrefied urine, therefore, contains chiefly the following substances, most of which are the products of putrefaction:

Ammonia,
Carbonat of ammonia,
Phosphat of ammonia,
Phosphat of magnesia and ammonia,
Urat of ammonia,
Acetite of ammonia,
Benzoat of ammonia,
Muriat of soda,
Muriat of ammonia;

Besides the precipitated gelatine and phosphat of lime *.

* Ann. de Chim xxxi. 70.

The distillation of urine produces almost the same changes; for the heat of boiling water is sufficient to decompose urea, and to convert it into ammonia, carbonic and acetous acids. Accordingly, when urine is distilled, there comes over water, containing ammonia dissolved in it, and carbonat of ammonia in crystals. The acids contained in urine are saturated with ammonia, and the gelatine and phosphat of lime precipitate †.

† Ibid, 55.

Such are the properties of the human urine. The urine of other animals has not hitherto been examined with equal care; but it is certain that it differs very considerably from that of men. The urine of cows and horses, and of all ruminating animals, for instance, contains carbonat of lime, without any mixture of phosphat of lime ‡. It contains also a much greater proportion of benzoic acid than that of man.

‡ Vauquelin, ibid. xxix. 4.

SECT. XVII. *Of the URINARY CALCULUS.*

IT is well known that concretions not unfrequently form in the bladder, or the other urinary organs, and occasion one of the most dismal diseases to which the human species is liable.

321 Urinary calculi.

These concretions were distinguished by the name of *calculi*, from a supposition that they are of a stony nature. They have long attracted the attention of physicians. Chemistry had no sooner made its way into medicine than it began to exercise its ingenuity upon the urinary calculus; and various theories were given of their nature and origin. According to Paracelsus, who gave them the ridiculous name of *duelech*, urinary calculi were intermediate between tartar and stone, and composed of an *animal resin*. Van Helmont pronounced them anomalous coagulations, the offspring of the salts of urine, and of a volatile earthy spirit, produced at once, and destitute of any viscid matter §. Boyle extracted from them, by distillation, oil, and a great quantity of volatile salt. Boerhaave supposed them compounds of oil and volatile salts. Hales extracted from them a prodigious quantity of air. He gave them the name of *animal tartar*, pointed out several circumstances in which they resemble common tartar, and made many experiments to find a solvent of them *. Drs Whytt and Alston pointed out alkalies as solvents of calculi. It was an attempt to discover a more perfect solvent that induced Dr Black to make those experiments which terminated in the discovery of the nature of the alkaline carbonats.

§ De Lithiasi, c. 3.

* Veget. Stat. ii. 189.

322 Analysed by Scheele.

Such was the state of the chemical analysis of calculus, when, in 1776, Scheele published a dissertation on the subject in the *Stockholm Transactions*; which was succeeded by some remarks of Mr Be [illegible]a. These

illustrious

Urinary Calculi.

illuſtrious chemiſts completely removed the uncertainty which had hitherto hung over the ſubject, and aſcertained the nature of the calculi which they examined. Since that time conſiderable additional light has been thrown upon the nature of theſe concretions by the labours of Auſtin, Pearſon, and, above all, of Fourcroy and Vauquelin, who have lately analyſed above 300 calculi, and aſcertained the preſence of ſeveral new ſubſtances which had not been ſuſpected. The ſubſtances hitherto diſcovered in urinary calculi are the following:

323 Their component parts.

1. Uric acid,
2. Urat of ammonia,
3. Phoſphat of lime (q),
4. Phoſphat of magneſia-and-ammonia,
5. Oxalat of lime,
6. Silica,
7. An animal matter.

324 Uric acid.

1. The greater number of calculi conſiſt of uric acid. All thoſe analyſed by Scheele were compoſed of it entirely. Of 300 calculi analyſed by Dr Pearſon, ſcarcely one was found which did not contain a conſiderable quantity of it, and the greater number manifeſtly were formed chiefly of it. Fourcroy and Vauquelin found it alſo in the greater number of the 300 calculi which they analyſed.

The preſence of this acid may eaſily be aſcertained by the following properties: A ſolution of potaſs or ſoda diſſolves it readily, and it is precipitated by the weakeſt acids. The precipitate is ſoluble in nitric acid, the ſolution is of a pink colour, and tinges the ſkin red *.

* Fourcroy, Ann. de Chim. xxxii. 216.

325 Urat of ammonia.

2. Urat of ammonia is eaſily detected by its rapid ſolubility in fixed alkaline leys, and the odour of ammonia which is perceived during the ſolution. It is not ſo often preſent in urinary calculi as the laſt mentioned ſubſtance. No calculus has hitherto been found compoſed of it alone, except the very ſmall polygonal calculi, ſeveral of which ſometimes exiſt in the bladder together.

It is moſt uſually in thin layers, alternating with ſome other ſubſtances, very eaſily reduced to powder, and of the colour of ground coffee †.

† Ibid. 218.

316 Phoſphat of lime.

3. Phoſphat of lime is white, without luſtre, fiery, friable, ſtains the hands, paper, and cloth. It has very much the appearance of chalk, breaks under the forceps, is inſipid, and inſoluble in water. It is ſoluble in nitric, muriatic, and acetous acids, and is again precipitated by ammonia, fixed alkalies, and oxalic acid.

It is never alone in calculi. It is intimately mixed with a gelatinous matter, which remains under the form of a membrane when the earthy part is diſſolved by very diluted acids ‡.

‡ Ibid.

317 Phoſphat of magneſia-and-ammonia.

4. Phoſphat of magneſia-and-ammonia occurs in white, ſemitranſparent, lameller layers; ſometimes it is cryſtallized on the ſurface of the calculi in priſms, or what are called *dog-tooth* cryſtals. It has a weak ſweetiſh taſte, it is ſomewhat ſoluble in water, and very ſoluble in acids, though greatly diluted. Fixed alkalies decompoſe it.

It never forms entire calculi. Sometimes it is mixed with phoſphat of lime, and ſometimes layers of it cover uric acid or oxalat of lime. It is mixed with the ſame gelatinous matter as phoſphat of lime ‡.

‡ Fourcroy, Ann. de Chim. xxxii. 219.

318 Oxalat of lime.

5. Oxalat of lime is found in certain calculi, which, from the inequality of their ſurface, have got the name of *moriform* or *mulberry ſhaped* calculi. It is never alone, but combined with a peculiar animal matter, and forming with it a very hard calculus, of a grey colour, difficult to ſaw aſunder, admitting a poliſh like ivory, exhaling, when ſawed, an odour like that of ſemen. Inſoluble and indecompoſible by alkalies; ſoluble in very diluted nitric acid, but ſlowly, and with difficulty. It may be decompoſed by the carbonats of potaſs and ſoda. When burnt, it leaves behind a quantity of pure lime, which may be eaſily recogniſed by its properties *.

* Ibid. 220.

329 Silica.

6. Silica has only been found in two inſtances by Fourcroy and Vauquelin, though they analyſed 300 calculi. No other chemiſt has obſerved it. It muſt therefore be conſidered as a very uncommon ingredient of theſe concretions. In the two inſtances in which it occurred, it was mixed with uric acid and the two phoſphats above mentioned †.

† Ibid. 221.

330 Animal matters.

7. *Animal matter* appears to compoſe the cement which binds the different particles of the calculus together, and in all probability it is the cauſe which influences its formation. It is different in different calculi. Sometimes it has the appearance of gelatine or albumen, at other times it reſembles urea. It deſerves a more accurate inveſtigation ‡.

‡ Ibid.

No general deſcription of the different calculi has hitherto appeared; but Fourcroy and Vauquelin are at preſent occupied with that ſubject. They propoſe to claſſify them according to their compoſition; to point out their different ſpecies and varieties; to give a method of detecting them by their appearance; to analyſe the animal matter by which they are cemented; and to apply all the preſent chemical knowledge of the ſubject in the inveſtigation of the cauſe, the ſymptoms, and the cure, of that dreadful diſeaſe which the urinary calculi produce. As their labour is already very far advanced, it would be unneceſſary for us to attempt any claſſification of calculi. Indeed every attempt of that kind, by any perſon who has not had an opportunity of analyſing a very great number of calculi, muſt be ſo exceedingly imperfect as ſcarcely to be of any uſe.

We ſhall ſatisfy ourſelves with the following remarks, deduced almoſt entirely from the obſervations which theſe celebrated chemiſts have already publiſhed.

331 Method of diſſolving the calculi.

Many calculi conſiſt entirely, or almoſt entirely, of uric acid. The animal matter, which ſerves as a cement to theſe calculi, appears to be urea. Calculi of this kind may be diſſolved by injecting into the bladder ſolutions of pure potaſs or ſoda, ſo much diluted as not to act upon the bladder itſelf. The gritty ſubſtance, which many perſons threatened with the ſtone diſcharge along with their urine, which has been called *gravel*, conſiſts almoſt conſtantly of uric acid. It may therefore ſerve as an indication that the ſubſequent ſtone, if any ſuch form, is probably compoſed of uric acid.

The two phoſphats, mixed together, ſometimes compoſe calculi. Theſe calculi are very brittle, and generally

(q) Brugnatelli found alſo phoſphat of lime, with exceſs of acid, in calculi. See *Ann. de Chim.* xxxii. 183.

Urinary Calculus.

rally break in pieces during the extraction. Such calculi may be dissolved by injecting into the bladder muriatic acid, so much diluted as scarcely to have any taste of acid.

The phosphats never form the nucleus of a calculus. They have never been found covered with a layer of uric acid, but they often cover that acid. Hence it would seem that the existence of any extraneous matter in the bladder disposes these phosphats to crystallize. When extraneous bodies are accidentally introduced into the bladder, and allowed to lodge there, they are constantly covered with a coat of phosphat of ammonia and magnesia, or of the two phosphats mixed.

As the phosphat of ammonia and magnesia is not an ingredient of fresh urine, but formed during its putrefaction, when it exists in calculi, it would seem to indicate a commencement of putrefaction during the time that the urine lodges in the bladder. But putrefaction does not take place speedily in urine, unless where there is an excess of albumen and gelatine; consequently we have reason to suppose, that these substances are morbidly abundant in the urine of those patients who are afflicted with calculi consisting of the phosphats: hence also we may conclude, that their digestion is imperfect. It will no doubt be objected, that dropsical people are not peculiarly subject to calculi; but their urine is only morbidly albuminous when the disease is beginning to disappear, and then there seems to be a deficiency of urea; at least their urine has not been observed to putrefy with uncommon rapidity. Besides, there seems to be some animal matter present, which serves as a cement to the phosphat in all cases where calculi form.

Urat of ammonia is only found alone in the very small polygonous calculi which exist, several together, in the bladder. In other cases it is mixed with uric acid. It sometimes alternates with uric acid or with the phosphats. It is dissolved by the same substance that acts as a solvent of uric acid.

Oxalat of lime often forms the nucleus of calculi composed of layers of uric acid or of the phosphats. It forms those irregular calculi which are called *moriform*. These calculi are the hardest and the most difficult of solution. A very much diluted nitric acid dissolves them but very slowly. As oxalic acid does not exist in urine, some morbid change must take place in the urine when such calculi are deposited. Brugnatelli's discovery of the instantaneous conversion of uric acid into oxalic acid by oxy-muriatic acid, which has been confirmed by the experiments of Fourcroy and Vauquelin, throws considerable light upon the formation of oxalic acid in urine, by shewing us that uric acid is probably the basis of it; but in what manner the change is actually produced, it is not so easy to say.

The calculi found in the bladder of other animals have not been examined with the same care. Some of them, however, have been subjected to an accurate analysis. No uric acid has ever been found in any of them.

132 Calculi of inferior animals.

Fourcroy found a calculus extracted from the kidney of a horse composed of three parts of carbonat of lime, and one part phosphat of lime *. Dr Pearson examined a urinary calculus of a horse; it was composed of phosphat of lime and phosphat of ammonia. Brugnatelli found a calculus extracted from the bladder of a sow, which was exceedingly hard, composed of pure carbonat of lime, inclosing a soft nucleus of a fœtid and urinous odour †. Bartholdi examined another calculus of a pig, the specific gravity of which was 1.9000. It consisted of phosphat of lime ‡. Dr Pearson found a calculus taken from the bladder of a dog composed of phosphat of lime, phosphat of ammonia, and an animal matter. He found the urinary calculus of a rabbit, of the specific gravity 2, composed of carbonat of lime and some animal matter ||.

* Chim. xvi. 95.
† Ibid. xxxii. 184.
‡ Ibid. 185.
|| Phil. Mag. ii. 134.

The composition of the different animal concretions hitherto examined may be seen in the following table.

Horse.	1. Carbonat of lime and phosphat of lime *.	* Fourcroy.
	2. Phosph. of lime and phosph. of ammonia †.	† Pearson.
	3. Carbon. of lime and animal matter †.	
Sow.	1. Carbon. of lime and an animal nucleus ‡.	‡ Brugnatelli.
	2. Phosphat of lime ¶.	¶ Bartholdi.
Dog.	Phosphat of lime, and of ammonia, and animal matter †.	† Pearson.
Rabbit.	Carbonat of lime and animal matter †.	

We have now given an account of all those secretions which have been attentively examined by chemists. The remainder have been hitherto neglected; partly owing to the difficulty of procuring them, and partly on account of the multiplicity of other objects which occupied the attention of chemical philosophers (x). It remains for us now to examine by what processes these different secretions are formed, how the constant waste of living bodies is repaired, and how the organs themselves are nourished and preserved. This shall form the subject of the following chapter.

Chap. III. Of the Functions of Animals.

The intention of the two last chapters was to exhibit a view of the different substances which enter into the composition of animals, as far as the present limited state of our knowledge puts it in our power. But were our enquiries concerning animals confined to the mere ingredients of which their bodies are composed, even supposing the analysis as complete as possible, our knowledge of the nature and properties of animals would be imperfect indeed.

How are these substances arranged? How are they produced?

(x) The chief of these secretions are the following:

1. Cerumen, or ear-wax, is at first nearly liquid, and of a whitish colour. It gradually acquires consistence. Its taste is very bitter. Said to be insoluble in alcohol; but soluble in hot water. Does not become rancid by keeping.
2. The humours of the eye.
3. The milky liquor, secreted by the thyroid gland.
4. Mucus of the lungs, intestinal canal, &c.
5. Smegma of the areola of the breasts, glans penis, vagina, subcutaneous glands, &c.
6. Marrow.

Functions of Animals produced? What purposes do they serve? What are the distinguishing properties of animals, and the laws by which they are regulated?

333 Animals resemble vegetables. Animals resemble vegetables in the complexness of their structure. Like them, they are machines nicely adapted for particular purposes, constituting one whole, and continually performing an infinite number of the most delicate processes. But neither an account of the structure of animals, nor of the properties which distinguish them from other beings, will be expected here. These have been already treated of sufficiently in the articles ANATOMY and PHYSIOLOGY (*Encycl.*), to which we beg leave to refer the reader. We mean only, in the present chapter, to take a view of those processes which are concerned in the *production* of animal substances, which alone properly belong to chemistry. The other functions are regulated by laws of a very different nature, which have no resemblance or analogy to the laws of chemistry or mechanics.

334 Require food. 1. Every body knows that animals require food, and that they die sooner or later if food be withheld from them. There is indeed a very great difference in different animals, with regard to the quantity of food which they require, and the time which they can pass without it. In general, this difference depends upon the activity of the animal. Those which are most active require most, and those which move least require least food.

The cause of this is also well known; the bodies of animals do not remain stationary, they are constantly wasting; and the waste is generally proportional to the activity of the animal. It is evident, then, that the body must receive, from time to time, new supplies, in place of what has been carried off. Hence the use of food, which answers this purpose.

335 Its nature. 2. We are much better acquainted with the food of animals than of vegetables. It consists of almost all the animal and vegetable substances which have been treated of in the former part of this article; for there are but few of them which some animal or other does not use as food. Man uses as food chiefly the muscles of animals, the seeds of certain grasses, and a variety of vegetable fruits. Almost all the inferior animals have particular substances on which they feed exclusively. Some of them feed on animals, others on vegetables. Man has a greater range; he can feed on a very great number of substances. To enumerate these substances would be useless; as we are not able to point out with accuracy what it is which renders one substance more nourishing than another.

Many substances do not serve as nourishment at all; and not a few, instead of nourishing, destroy life. These last are called *poisons*. Some poisons act chemically, by decomposing the animal body. The action of others is not so well understood.

336 Converted into chyme. 3. The food is introduced into the body by the mouth, and almost all animals reduce it to a kind of pulpy consistence. In man and many other animals this is done in the mouth by means of teeth, and the saliva with which it is there mixed; but many other animals grind their food in a different manner. See PHYSIOLOGY, (*Encycl.*) After the food has been thus ground, it is introduced into the stomach, where it is subjected to new changes. The stomach is a strong soft bag, of different forms in different animals: in man it has some resemblance to the bag of a *bag-pipe*. In this organ the food is converted into a soft pap, which has no resemblance to the food when first introduced. This pap has been called *chyme*. Functions of Animals.

4. Since chyme possesses new properties, it is evident that the food has undergone some changes in the stomach, and that the ingredients of which it was composed have entered into new combinations. Now, in what manner have these changes been produced?

At first they were ascribed to the mechanical action of the stomach. The food, it was said, was still farther triturated in that organ; and being long agitated backwards and forwards in it, was at last reduced to a pulp. But this opinion, upon examination, was found not to be true. The experiments of Stevens, Reaumur, and Spallanzani, demonstrated, that the formation of chyme is not owing to trituration; for on inclosing different kinds of food in metallic tubes and balls full of holes, in such a manner as to screen them from the mechanical action of the stomach, they found, that these substances, after having remained a sufficient time in the stomach, were converted into chyme, just as if they had not been inclosed in such tubes. Indeed, the opinion was untenable, even independent of these decisive experiments, the moment it was perceived that chyme differed entirely from the food which had been taken; that is to say, that if the same food were triturated mechanically out of the body, and reduced to pap of precisely the same consistence with chyme, it would not possess the same properties with chyme; for whenever this fact was known, it could not but be evident that the food had undergone changes in its composition.

The change of food into chyme, therefore, was ascribed by many to *fermentation*. This opinion is indeed very ancient, and it has had many zealous supporters among the moderns. When the word *fermentation* was applied to the change produced on the food in the stomach, the nature of the process called fermentation was altogether unknown. The appearances, indeed, which take place during that process, had been described, and the progress and the result of it were known. Chemists had even divided fermentations into different classes; but no attempt had been made to explain the cause of fermentation, or to trace the changes which take place during its continuance. All that could be meant, then, by saying that the conversion of food into chyme in the stomach was owing to fermentation, was merely, that the unknown cause which acted during the conversion of vegetable substances into wine or acid, or during their putrefaction, acted also during the conversion of the food into chyme, and that the result in both cases was precisely the same. Accordingly, the advocates for this opinion attempted to prove, that air was constantly generated in the stomach, and that an acid was constantly produced: for it was the vinous and acetous fermentations which were assigned by the greater number of physiologists as the cause of the formation of chyme. Some indeed attempted to prove, that it was produced by the putrefactive fermentation; but their number was inconsiderable, compared with those who adopted the other opinion.

Our ideas respecting fermentation are now somewhat more precise. It signifies a slow decomposition, which takes place when certain animal or vegetable substances are mixed together at a given temperature; and the

consequent production of particular compoun[illegible] If therefore the conversion of the food into chyme be owing to fermentation, it is evident that i[illegible]tally independent of the stomach any farther th[illegible]s it supplie[illegible] temperature; and that the food would [illegible] converted into chyme exactly in the same manner, [illegible] were reduced to the same consistence, and placed in the same temperature out of the body. But this is by no means the case; substances are reduced to the state of chyme in a short time in the stomach, which would remain unaltered for weeks in the same temperature out of the body. This is the case with bones; which the experiments of Stevens and Spallanzani have shewn to be soon digested in the stomach of the dog. Farther, if the conversion of food into chyme were owing to fermentation, it ought to go on equally well in the stomach and œsophagus. Now, it was observed long ago by Ray and Boyle, that when voracious fish had swallowed animals too large to be contained in the stomach, that part only which was in the stomach was converted into chyme, while what was in the œsophagus remained entire; and this has been fully confirmed by subsequent observations.

Still farther, if the conversion were owing to fermentation, it ought always to take place equally well, provided the temperature be the same, whether the stomach be in a healthy state or not. But it is well known, that this is not the case. The formation of chyme depends very much on the state of the stomach. When that organ is diseased, digestion is constantly ill performed. In these cases, indeed, fermentation sometimes appears, and produces flatulence, acid eructations, &c. which are the well-known symptoms of indigestion. These facts have been long known; they are totally incompatible with the supposition, that the formation of chyme is owing to fermentation. Accordingly that opinion has been for some time abandoned, by all those at least who have taken the trouble to examine the subject.

337 By the action of the gastric juice.

The formation of chyme, then, is owing to the stomach; and it has been concluded, from the experiments of Stevens, Reaumur, Spallanzani, Scopoli, Brugnatelli, Carimini, &c. that its formation is brought about by the action of a particular liquid secreted by the stomach, and for that reason called *gastric juice*.

That it is owing to the action of a liquid, is evident; because if pieces of food be inclosed in close tubes, they pass through the stomach without any farther alteration than would have taken place at the same temperature out of the body: but if the tubes be perforated with small holes, the food is converted into chyme.

This liquid does not act indiscriminately upon all substances: For if grains of corn be put into a perforated tube, and a granivorous bird be made to swallow it, the corn will remain the usual time in the stomach without alteration; whereas if the husk of the grain be previously taken off, the whole of it will be converted into chyme. It is well known, too, that many substances pass unaltered through the intestines of animals, and consequently are not acted upon by the gastric juice. This is the case frequently with grains of oats when they have been swallowed by horses entire with their husks on. This is the case also with the seeds of apples, &c. when swallowed entire by man; yet these very substances, if they have been previously ground sufficiently by the teeth, are digested. It appears, therefore, that it is chiefly the husk or outside of these substances which resists the action of the gastric juice. We see also, that trituration greatly facilitates the conversion of food into chyme.

338 Nature of gastric juice.

The gastric juice is not the same in all animals; for many animals cannot digest the food on which others live. The *conium maculatum* (hemlock), for instance, is a poison to man instead of food, yet the goat often feeds upon it. Many animals, as sheep, live wholly upon vegetables; and if they are made to feed on animals, their stomachs will not digest them: others, again, as the eagle, feed wholly on animal substances, and cannot digest vegetables.

The gastric juice does not continue always of the same nature, even in the same animal: it changes gradually, according to circumstances. Graminivorous animals may be brought to live on animal food; and after they have been accustomed to this for some time, their stomachs become incapable of digesting vegetables. On the other hand, those animals which naturally digest nothing but animal food may be brought to digest vegetables.

What is the nature of the gastric juice, which possesses these singular properties? It is evidently different in different animals; but it is a very difficult task, if not an impossible one, to obtain it in a state of purity. Various attempts have indeed been made by very ingenious philosophers to procure it; but their analysis of it is sufficient to shew us, that they have never obtained it in a state of purity.

The methods which have been used to procure gastric juice are, *first*, to kill the animal whose gastric juice is to be examined after it has fasted for some time. By this method, Spallanzani collected 37 spoonfuls from the two first stomachs of a sheep. It was of a green colour, undoubtedly owing to the grass which the animal had eaten. He found also half a spoonful in the stomach of some young crows which he killed before they had left their nest.

Small tubes of metal, pierced with holes, and containing a dry sponge, have been swallowed by animals; and when vomited up, the liquid imbibed by the sponge is squeezed out. By this method, Spallanzani collected 481 grains of gastric juice from the stomachs of five crows.

A *third* method consists in exciting vomiting in the morning, when the stomach is without food. Spallanzani tried this method twice upon himself, and collected one of the times 1 oz. 32 gr. of liquid; but the pain was so great, that he did not think proper to try the experiment a third time. Mr Gosse, however, who could excite vomiting whenever he thought proper by swallowing air, has employed that method to collect gastric juice.

Spallanzani has observed, that eagles throw up every morning a quantity of liquid, which he considers as gastric juice; and he has availed himself of this to collect it in considerable quantities.

It is almost unnecessary to remark how imperfect these different methods are, and how far every conclusion drawn from the examination of such juices must deviate from the truth. It is impossible that the gastric juice, obtained by any one of these processes, can be pure; because in the stomach it must be constantly mixed

mixed with larg[e] quantities of faliva, mucus, bile, food, &c. It may be queftioned, indeed, whether any gaftric juice at all can be obtained by thefe methods: for as the intention of the gaftric juice is to convert the f[ood] into chyme, in all probability it is only fecreted, or at leaft thrown into the ftomach when food is prefent.

We need not be furprifed, then, at the contradictory accounts concerning its nature, given us by thofe philofophers who have attempted to examine it; as thefe relate not fo much to the gaftric juice, as to the different fubftances found in the ftomach. The idea that the gaftric juice can be obtained by vomiting, or that it is thrown up fpontaneoufly by fome animals, is, to fay the leaft of it, very far from being probable.

According to Brugnatelli, the gaftric juice of carnivorous animals, as hawks, kites, &c. has an acid and refinous odour, is very bitter, and not at all watery; and is compofed of an uncombined acid, a refin, an animal fubftance, and a fmall quantity of muriat of foda *. The gaftric juice of herbivorous animals, on the contrary, as goats, fheep, &c. is very watery, a little muddy, has a bitter faltifh tafte, and contains ammonia, an animal extract, and a pretty large quantity of muriat of foda †. Mr Carminati found the fame ingredients; but he fuppofes that the ammonia had been formed by the putrefaction of a part of their food, and that in reality the gaftric juice of thefe animals is of an acid nature ‡.

The accounts which have been given of the gaftric juice of man are fo various, that it is not worth while to tranfcribe them. Sometimes it has been found of an acid nature, at other times not. The experiments of Spallanzani are fufficient to fhew, that this acidity is not owing to the gaftric juice, but to the food. He never found any acidity in the gaftric juice of birds of prey, nor of ferpents, frogs, and fifhes. Crows gave an acidulous gaftric juice only when fed on grain; and he found that the fame [illegible] holds with refpect to dogs, [illegible] domeftic fowls. Carnivorous birds threw up pieces of fhells and coral without alteration; but thefe fubftances were fenfibly diminifhed in the ftomachs of hens, even when inclofed in perforated tubes. Spallanzani himfelf fwallowed calcareous fubftances inclofed in tubes; and when he fed on vegetables and fruits, they were fometimes altered and a little diminifhed in weight, juft as if they had been put into weak vinegar; but when he ufed only animal food, they came out untouched. According to this philofopher, whofe experiments have been by far the moft numerous, the gaftric juice is naturally neither acid nor alkaline. When poured on the carbonat of potafs, it caufes no effervefcence.

Such are the refults of the experiments on the juices taken from the ftomach of animals. No conclufion can be drawn from them refpecting the nature of the gaftric juice. But from the experiments which have been made on the digeftion of the ftomach, efpecially by Spallanzani, the following facts are eftablifhed.

The gaftric juice attacks the furfaces of bodies, unites to the particles of them which it carries off, and cannot be feparated from them by filtration. It operates with more energy and rapidity the more the food is divided, and its action is increafed by a warm temperature. The food is not merely reduced to very minute parts; its tafte and fmell are quite changed; its fenfible properties are deftroyed, and it acquires new and very different ones. This juice does not act as a ferment; fo far from it, that it is a powerful antifeptic, and even reftores flefh already putrefied. There is not the fmalleft appearance of fuch a procefs; indeed, when the juice is renewed frequently, as in the ftomach, fubftances diffolve in it with a rapidity which excludes all idea of fermentation. Only a few air bubbles make their efcape, which adhere to the alimentary matter, and buoy it up to the top, and which are probably extricated by the heat of the folution.

Functions of Animals.

With refpect to the fubftances contained in the ftomach, only two facts have been perfectly afcertained: The firft is, that the juice contained in the ftomach of oxen, calves, fheep, invariably contains uncombined phofphoric acid, as Macquart and Vauquelin have demonftrated: The fecond, that the juice contained in the ftomach, and even the inner coat of the ftomach itfelf, has the property of coagulating milk and the ferum of blood. Dr Young found, that feven grains of the inner coat of a calf's ftomach, infufed in water, gave a liquid which coagulated more than 10[0] ounces of milk; that is to fay, more than 6857 times its own weight; and yet, in all probability, its weight was not much diminifhed.

What the fubftance is which poffeffes this coagulating property, has not yet been afcertained; but it is evidently not very foluble in water: for the infide of a calf's ftomach, after being fteeped in water for fix hours, and then well wafhed with water, ftill furnifhes a liquor on infufion which coagulates milk *: And Dr Young found, that a piece of the inner coat of the ftomach, after being previoufly wafhed with water, and then with a diluted folution of carbonat of potafs, ftill afforded a liquid which coagulated milk and ferum.

It is evident, from thefe facts, that this coagulating fubftance, whatever it is, acts very powerfully; and that it is fcarcely poffible to feparate it completely from the ftomach. But we know at prefent too little of the nature of coagulation to be able to draw any inference from thefe facts. An almoft imperceptible quantity of fome fubftances feems to be fufficient to coagulate milk. For Mr Vaillant mentions in his Travels in Africa, that a porcelain difh which he procured, and which had lain for fome years at the bottom of the fea, poffeffed, in confequence, the property of coagulating milk when put into it; yet it communicated no tafte to the milk, and did not differ in appearance from other cups.

It is probable that the faliva is of fervice in the converfion of food into chyme as well as the gaftric juice. It evidently ferves to dilute the food, and probably it may be ferviceable alfo, by communicating oxygen.

5. The chyme, thus formed, paffes from the ftomach into the inteftines, where it is fubjected to new changes, and at laft converted into two very different fubftances, chyle and excrementitious matter. [illegible]

6. The *chyle* is a white coloured liquid, very much refembling milk. It is exceedingly difficult to collect it in any confiderable quantity, and for that reafon it has never been accurately analyfed. We know only in general that it refembles milk; containing, like it, an albuminous part capable of being coagulated, a ferum, and globules which have a refemblance to cream. It contains alfo different falts; and, according to [illegible], a fubftance fcarcely differing from the fugar of milk. It is probable alfo that it contains iron; but if fo, it muft be

* Young[illegible]

be in the state of a white oxyd; for an infusion of nut galls does not alter the colour of chyle ‡.

6. Concerning the process by which chyle is formed from chyme, scarcely any thing is known. It does not appear that the chyme is precisely the same in all animals; for those which are herbivorous have a greater length of intestine than those which are carnivorous. It is certain that the formation of the chyle is brought about by a chemical change, although we cannot say precisely what that change is, or what the agents are by which it is produced. But that the change is chemical, is evident, because the chyle is entirely different, both in its properties and appearance, from the chyme. The chyme, by the action of the intestines, is separated into two parts, chyle and excrement: the first of which is absorbed by a number of small vessels called *lacteals*; the second is pushed along the intestinal canal, and at last thrown out of the body altogether.

After the chyme has been converted into chyle and excrement, although these two substances remain mixed together, it does not appear that they are able to decompose each other; for persons have been known seldom or never to emit any excrementitious matter *per anum* for years. In these, not only the chyle, but the excrementitious matter also, was absorbed by the lacteals; and the excrement was afterwards thrown out of the body by other outlets, particularly by the skin: in consequence of which, those persons have constantly that particular odour about them which distinguishes excrement. Now in these persons, it is evident that the chyle and excrement, though mixed together, and even absorbed together, did not act on each other; because these persons have been known to enjoy good health for years, which could not have been the case had the chyle been destroyed.

It has been supposed by some that the decomposition of the chyme, and the formation of chyle, is produced by the agency of the bile, which is poured out abundantly, and mixed with the chyme, soon after its entrance into the intestines. If this theory were true, no chyle could be formed whenever any accident prevented the bile from passing into the intestinal canal: but this is obviously not true; for frequent instances have occurred of persons labouring under jaundice from the bile ducts being stopped, either by gallstones or some other cause, so completely, that no bile could pass into the intestines; yet these persons have lived for a considerable time in that state. Consequently digestion, and therefore the formation of chyle, must be possible, independent of bile.

The principal use of the bile seems to be to separate the excrement from the chyle, after both have been formed, and to produce the evacuation of the excrement out of the body. It is probable that these substances would remain mixed together, and that they would perhaps even be partly absorbed together, were it not for the bile, which seems to combine with the excrement, and by this combination to facilitate its separation from the chyle, and thus to prevent its absorption. It also stimulates the intestinal canal, and causes it to evacuate its contents sooner than it otherwise would do; for when there is a deficiency of bile, the body is constantly costive.

341 Of the excrementitious matter.

8. The excrement, then, which is evacuated *per anum*, consists of all that part of the food and chyme which was not converted into chyle, entirely altered however from its original state, partly by the decomposition which it underwent in the stomach and intestines, and partly by its combination with bile. Accordingly we find in it many substances which did not exist at all in the food. Thus in the dung of cows and horses there is found a very considerable quantity of benzoic acid. The excrements of animals have not yet been subjected to an accurate analysis, though such an analysis would throw much light upon the nature of digestion. For if we knew accurately the substances which were taken into the body as food, and all the new substances which were formed by digestion; that is to say, the component parts of chyle and of excrement, and the variation which different kinds of food produce in the excrement, it would be a very considerable step towards ascertaining precisely the changes produced on food by digestion, or, which is the same thing, towards ascertaining exactly the phenomena of digestion. The only analysis which has hitherto been made on human excrement is that of Homberg; and as it consisted merely in subjecting it to distillation, it is needless to give an account of it. Of late, as Mr Fourcroy informs us, the subject has been resumed in France, and we may soon expect some very curious and important additions to our knowledge.

342 Excrements of fowls.

Mr Vauquelin has already published an analysis of the fixed parts of the excrements of fowls, and a comparison of them with the fixed parts of the food; from which some very curious consequences may be deduced.

He found that a hen devoured in ten days 11111.843 grains troy of oats. These contained

136.509 gr. of phosphat of lime,
219.548 silica,
———
356.057.

During these ten days she layed four eggs; the shells of which contained 98.776 gr. phosphat of lime, and 453.417 gr. carbonat of lime. The excrements emitted during these ten days contained 17[illegible] gr. phosphat of lime, 58.49[illegible] gr. of carbonat of lime, 185.266 gr. of silica. Consequently the fixed thrown out of the system during these ten days amounted to

Grains.
274.305 phosphat of lime,
511.911 carbonat of lime,
185.266 silica,
———
Given out 971.482
Taken in 356.057
———
615.425

Consequently the quantity of fixed matter given out of the system in ten days exceeded the quantity taken in by 615.425 grains.

The silica taken in amounted to	219.548 gr.
That given out was only	185.266 gr.
Remains	34.282

Consequently there disappeared 34.282 grains of silica.

The phosphat of lime taken in was	136.509 gr.
That given out was	274.305 gr.
	137.796

Consequently

‡ Fordyce on Digestion, 121.

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Consequently there must have been formed, by digestion in this fowl, no less than 137.796 grains of phosphat of lime, besides 511.911 grains of carbonat. Consequently lime (and perhaps also phosphorus) is not a simple substance, but a compound, and formed of ingredients which exist in oat-seed, water, or air, the only substance to which the fowl had access. Silica may enter into its composition, as a part of the silica had disappeared; but if so, it must be combined with a great quantity of some other substance *.

These consequences are too important to be admitted without a very rigorous examination. The experiment must be repeated frequently, and we must be absolutely certain that the hen has no access to any calcareous earth, and that she has not diminished in weight; because in that case some of the calcareous earth, of which part of her body is composed, may have been employed. This rigour is the more necessary, as it seems pretty evident, from experiments made long ago, that *some* birds at least, cannot produce eggs unless they have access to calcareous earth. Dr Fordyce found, that if the canary bird was not supplied with lime at the time of her laying, she frequently died, from her eggs not coming forward properly †. He divided a number of these birds at the time of their laying eggs, into two parties: to the one he gave a piece of old mortar, which the little animals swallowed greedily; they laid their eggs as usual, and all of them lived: whereas many of the other party, which were supplied with no lime, died ‡.

* *Ann. de Chim.* xxix 26.

† *On Digestion*, p. 25.

‡ *Ibid.* p. 26.

[342] Gases contained in the intestines.

9. The intestines seldom or never are destitute of gases, which seem to be evolved during the process of digestion §, and may therefore, in part, be considered as excrementitious matter. The only person who has examined these gases with care, is Mr Jurine of Geneva. The result of his analysis is as follows. He found in the stomach and intestines of a man who had been frozen to death, carbonic acid gas, oxygen gas, hydrogen gas, and azotic gas. The quantity of carbonic acid was greatest in the stomach, and diminished gradually as the canal receded from the stomach; the proportion of oxygen gas was considerable in the stomach, smaller in the small intestines, and still smaller in the great intestines; the hydrogen and azotic gases, on the contrary, were least abundant in the stomach, more abundant in the small intestines, and most abundant in the larger intestines; the hydrogen gas was most abundant in the small intestines. It is well known that the flatus discharged *per anum* is commonly carbonated hydrogen gas; sometimes also it seems to hold sulphur, or even phosphorus in solution §.

§ *Encyc. Meth. Med.* 516.

343 Chyle in the thoracic duct,

10. The chyle, after it has been absorbed by the lacteals, is carried by them into a pretty large vessel, known by the name of *thoracic duct*. Into the same vessel likewise is discharged a transparent fluid, conveyed by a set of vessels which arise from all the cavities of the body. These vessels are called *lymphatics*, and the fluid which they convey is called *lymph*. In the thoracic duct, then, the chyle and the lymph are mixed together.

344 Mixed with the lymph,

Very little is known concerning the nature of the *lymph*, as it is scarcely possible to collect it in any quantity. It is colourless, has some viscidity, and is said to be specifically heavier than water. It is said to be coagulable by heat; if so, it contains albumen; and, from its appearance, it probably contains gelatine. Its quantity is certainly considerable, for the lymphatics are very numerous.

11. The chyle and lymph being thus mixed together, are conveyed directly into the blood vessels. The effect produced by their union in the thoracic duct is not known, but neither the colour nor external properties of the chyle is altered. In man, and many other animals, the thoracic duct enters at the junction of the left subclavian and carotid veins, and the chyle is conveyed directly to the heart, mixed with the blood which already exists in the blood vessels. From the heart, the blood and chyle thus mixed together are propelled into the lungs, where they undergo farther changes.

346 Respiration.

12. The absolute necessity of *respiration*, or of something analogous, is known to every one; and few are ignorant that in man, and hot blooded animals, the organ by which respiration is performed is the lungs. For a description of the respiratory organs, we refer to the article ANATOMY, *Encycl.* and the reader will find an account of the manner in which that function is performed in the article PHYSIOLOGY, *Encycl.* But what are the changes produced upon the blood and the chyle by respiration? What purposes does it serve to the animal? How comes it to be so indispensably necessary for its existence? These are questions which can only be answered by a careful examination of the phenomena of respiration.

347 Requires oxygen gas.

It has been long known that an animal can only breathe a certain quantity of air for a limited time, after which it becomes the most deadly poison, and produces suffocation as effectually as the most noxious gas, or a total absence of air. It was suspected long ago that this change is owing to the absorption of a part of the air; and Mayow made a number of very ingenious experiments in order to prove the fact. Dr Priestley and Mr Scheele demonstrated, that the quantity of oxygen gas in atmospheric air is diminished; and Lavoisier demonstrated, in 1776, that a quantity of carbonic acid gas, which did not previously exist in it, was found in air after it had been for some time respired. It was afterwards proved by Lavoisier, and many other philosophers, who confirmed and extended his facts, that no animal can live in air totally destitute of oxygen. Even fish, which do not sensibly respire, die very soon, if the water in which they live be deprived of oxygen gas. Frogs which can suspend their respiration at pleasure, die in about forty minutes, if the water in which they have been confined be covered over with oil *. Insects and worms, as Vauquelin has proved, exhibit precisely the same phenomena. They require oxygen gas as well as other animals, and die like them if they be deprived of it. They diminish the quantity of the oxygen gas in which they live, and give out, by respiration, the very same products as other animals. Worms, which are more retentive of life than most other animals, or at least not so much affected by poisonous gases, absorb every particle of the oxygen gas contained in the air in which they are confined before they die. Mr Vauquelin's experiments were made on the gryllus viridissimus, the limax flavus, and helix pomatia †.

* *Carradori, Ann. de Chim.* xxix. 171.

† *Ann. de Chim.* xii. 278.

348 Changes produced by it.

The changes which take place during respiration are the following:

1. Part of the oxygen gas respired disappears.

2. Carbonic

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2. Carbonic acid gas is emitted.

3. Water is emitted in the state of vapour.

The first point is to ascertain exactly the amount of these changes. Though a great many experiments have been made on this subject by different philosophers, the greatest confidence ought to be put in those of Lavoisier, both on account of his uncommon accuracy, and on account of the very complete apparatus which he always employed.

He put a guinea-pig into 708.989 grains troy of oxygen, and after the animal had breathed the gas for an hour, he took it out. He found that the oxygen

gas now amounted only to	592.253 gr.
Consequently there had disappeared	116.736
The carbonic acid gas formed was	130.472
This was composed of about	94.234
oxygen, and	36.238

of carbon. Consequently supposing, as Mr Lavoisier did, that the oxygen absorbed had been employed in the formation of the carbonic acid gas, there still remained to be accounted for 22.502 grains of oxygen which had disappeared. He supposed that this had been employed in the formation of water, a quantity of which had appeared. If so, the water formed must have amounted to 26.429 grains; which was composed of 3.927 hydrogen, the rest oxygen *.

* Ann. de Chim. v. 261.

Since the water emitted was not actually ascertained, this experiment can only be considered as an approximation to the truth. Accordingly that very ingenious philosopher contrived an apparatus to ascertain the quantity of oxygen gas absorbed by man, and the quantity of carbonic acid gas and water emitted by him during respiration. This apparatus he had constructed at an expence at least equal to L. 500 sterling. The experiments were completed, and he was preparing them for publication, when, on the 8th of May 1794, he was beheaded by order of Robespierre, after having in vain requested a fortnight's delay to put his papers in order for the press. Thus perished, in the 51st year of his age, the man who, if he had lived a few years longer, promised fair to become the rival of Newton himself. Chemistry, as a science, is deeply indebted to him. He saved it from that confusion into which the thoughtless ardour of many of his contemporaries were plunging it headlong: he arranged and connected and simplified and explained the multitude of insulated facts, which had been accumulating with unexampled celerity; and which, had it not been for his happy arranging genius, might have retarded, instead of advanced, the progress of the science. He reduced all the facts under a few simple heads, and thus made them easily remembered and easily classified. In a few years more, perhaps, he would have traced these general principles to their sources, established the science on the completest induction, and paved for his successors a road as unerring as that which Sir Isaac Newton formed in mechanical philosophy.

Mr Lavoisier's experiments have never been published, but fortunately Mr de la Place has given us the result of them †. He informs us that it was as follows: A man, at an average, consumes, in twenty-four hours, by respiration, 32.48437 ounces troy of oxygen gas; that is to say, that a quantity of oxygen gas, equal to that weight, disappears from the air which he respires in twenty-four hours; that he gives out by respiration, in the same time, 15.73 oz. troy of carbonic acid gas, and 28.55 of water in the state of vapour.

† La Place's Eloge.

Total	44.28	*Oxygen.*
The carbonic acid gas is composed of and 5.243 carbon.		10.486
The water of and 4.2825 hydrogen.		24.2675
Total of the oxygen emitted		34.75416
Total absorbed		32.48437
So that there is		2.3697916

ounces of oxygen emitted more than is absorbed by respiration. Thus it appears that, by respiration, the absolute quantity of oxygen in the blood is diminished.

Dr Menzies found that a man, at a medium, draws in at every respiration 43.77 cubic inches of air, and that $\frac{1}{20}$th of that quantity disappears. Consequently, according to him, at every respiration 2.1885 cubic inches of oxygen gas are consumed. Now 2.1885 cubic inches of that gas amount to 0.68669 gr. troy. Supposing, with Hales, that a man makes 1200 respirations in an hour, the quantity of oxygen gas consumed in an hour, will amount to 824.028 grains, and in 24 hours to 19776.672 grains, or 41.2014 ounces troy. This quantity exceeds that found by Lavoisier considerably; but the allowance of oxygen for every respiration is rather too great. Indeed, from the nature of Dr Menzies's apparatus, it was scarce possible to measure it accurately.

The quantity of water given out by resp[illegible] determined by Hales, amounts in a day to [illegible] *; but his method was not susceptible of great accuracy. We may therefore, on the whole, consider Lavoisier's determination as by far the nearest to the truth of any that has been given.

* Veget. Stat. ii. 347.

There is, however, a very singular anomaly, which becomes apparent when we compare his experiments on the respiration of the guinea-pig with those on the respiration of man.

The guinea-pig consumed in 24 hours 5.8368 oz. troy of oxygen gas and emitted 6.5236 oz. of carbonic acid gas. Man, on the other hand, consumes in the same time 32.48437 oz. of oxygen gas, and emits only 15.73 oz. of carbonic acid gas. The oxygen gas consumed by the pig is to the carbonic gas emitted as 1.00 : 1.12; whereas in man it is as 1.000 : 0.484. If we could depend upon the accuracy of each of these experiments, they would prove, beyond a doubt, that the changes produced by the respiration of the pig are different, at least in degree, from those produced in man; but it is more than probable that some mistake has crept into one or other of the experiments. We have more reason to suspect the first, as it was made before 1778, at a time when a great many circumstances, necessary to insure accuracy, were unknown to Lavoisier.

Such are the substances imbibed and emitted during respiration. It still remains for us to determine what are the changes which it produces on the blood.

It has been long known that the blood which flows in the veins is of a dark reddish purple colour, whereas the arterial blood is of a florid scarlet colour. Lower observed that the colour of the veinous blood was converted into that of arterial during its passage through the

Functions of Animals. the lungs. No chyle can be distinguished by its white colour in the blood after it has passed through the lungs. The changes, then, which take place upon the appearance of the blood are two: 1*st*, It acquires a florid red colour; 2*d*, The chyle totally disappears. Now to what are these changes owing?

Lower himself knew that the change was produced by the air, and Mayow attempted to prove that it was by absorbing a part of the air. But it was not till Dr Priestley discovered that veinous blood acquires a scarlet colour when put in contact with oxygen gas, and arterial blood a dark red colour when put in contact with hydrogen gas, or, which is the same thing, that oxygen gas instantly gives veinous blood the colour of arterial; and hydrogen, on the contrary, gives arterial blood the colour of veinous blood: it was not till then that philosophers began to attempt any thing like an explanation of the phenomena of respiration. Two explanations have been given; one or other of which must be true.

349 Two hypotheses to explain these changes.

The first is, that the oxygen of the air, which disappears, combines with a quantity of carbon and hydrogen given out by the blood in the lungs, and forms with it carbonic acid gas and water in vapour, which are thrown out along with the air expired.

The second is, that the oxygen gas, which disappears, combines with the blood as it passes thro' the lungs; and that, at the instant of this combination, there is set free from the blood a quantity of carbonic acid gas and of water, which are thrown out along with the air expired.

The first of these theories was originally formed by Lavoisier, and it was embraced by La Place, Crawford, Gwen, and Girtanner, with a small variation. Indeed it does not differ, except in detail, from the original hypothesis of Dr Priestley, that the use of respiration is to rid the blood of phlogiston for if we substitute carbon and hydrogen for phlogiston, the two [illegible] precisely agree. Mr Lavoisier attempted not to pro[illegible] its truth; he only tried to shew that the oxygen absorbed corresponds exactly with the quantity of oxy[illegible] contained in the carbonic acid and the water emitted. This coincidence, however, experiments have shewn not to hold; consequently the [illegible] is entirely destitute of proof, as far as the proof depends upon this coincidence.

The other hypothesis was proposed by Mr de la Grange, and afterwards supported and illustrated by Mr Hassenfratz.

350 Effects of respiration examined.

In order to discover what the real effects of respiration are, let us endeavour to state accurately the phenomena as far as possible.

In the *first* place, we are certain, from the experiments of Priestley, Girtanner, and Hassenfratz, that when veinous blood is exposed to oxygen gas confined over it, the blood instantly assumes a scarlet colour, and the gas is diminished in bulk; therefore part of the gas has been absorbed. We may consider it as certain, then, that when the colour of veinous blood is changed into arterial, some oxygen gas is absorbed †.

In the *second* place, no chyle can be discovered in the blood after it has passed through the lungs. Therefore the *white colour* of the chyle at least, is destroyed by respiration, and it assumes a red colour. Now if the red colour of the blood be owing to iron, as many have supposed, this change of colour is a demonstration that oxygen has combined with the iron; for we have seen already, that iron, if it exists in chyle, as it probably does, is in the state of a white oxyd. Consequently, when converted into a red oxyd, it must absorb oxygen. Even though iron be not the colouring matter of the blood, it would still be probable that the change of colour of the chyle depends on the fixation of oxygen; for Berthollet and Fourcroy have shewn that in several instances substances acquire a red colour by that process.

We may consider it as proved, then, that oxygen enters the blood as it passes through the lungs.

In the *third* place, when arterial blood is put in contact with azotic gas, or carbonic acid gas, it gradually assumes the dark colour of veinous blood, as Dr Priestley found *. The same philosopher also observed that arterial blood acquired the colour of veinous blood when placed in vacuo †. Consequently this alteration of colour is owing to some change which takes place in the blood itself, independent of any external agent.

The arterial blood becomes much more rapidly and deeply dark coloured when it is left in contact with hydrogen gas placed above it ‡. We must suppose therefore that the presence of this gas accelerates and increases the change, which would have taken place upon the blood without any external agent.

If arterial blood be left in contact with oxygen gas, it gradually assumes the same dark colour which it would have acquired in vacuo, or in contact with hydrogen; and after this change oxygen can no longer restore its scarlet colour §. Therefore it is only upon a part of the blood that the oxygen acts; and after this part has undergone the change which occasions the dark colour, the blood loses the power of being affected by oxygen.

Mr Hassenfratz poured into veinous blood a quantity of oxy-muriatic acid; the blood was instantly decomposed, and assumed a deep and almost black colour. When he poured common muriatic acid into blood, the colour was not altered ‖. Now oxy muriatic acid has the property of giving out its oxygen readily; consequently the black colour was owing to the instant combination of a part of the blood with oxygen.

The facts therefore lead us to conclude, with La Grange and Hassenfratz, that during respiration the oxygen, which disappears, enters the blood; that during the circulation this oxygen combines with a certain part of the blood; and that the veinous colour is owing to this new combination. We must conclude, too, that the substance which causes this dark colour leaves the blood during its circulation thro' the lungs, otherwise it could not be capable of assuming the florid colour. Now we know what the substances are which are emitted during respiration; they are water and carbonic acid gas. It must be to the gradual combination of oxygen, then, during the circulation, with hydrogen and carbon, that the colour of veinous blood is owing. And since the same combination takes place every time that the blood passes through the lungs, we must conclude, that it is only a part of the hydrogen and carbon which is acted upon each time. Let us now attempt, with these data, to form some notion of the decomposition which goes on during the circulation of the blood.

351 Contributes to the formation of blood,

It is probable that, during a considerable part of the day, there is a constant influx of chyle into the blood; and we are certain that lymph is constantly flowing into

† *Ann de Chim.* vii. 148.

* *Priestley*, iii 363.

† *Ibid*, and *Ann de Chim.* ix. 269.

‡ *Fourcroy*, *Ann de Chim.* vii. 149.

§ *Ibid* ix. 268.

‖ *Ibid.*

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to it. Now it appears, from the most accurate observations hitherto made, that neither chyle nor lymph contain fibrina, which forms a very conspicuous part of the blood. This fibrina is employed to supply the waste of the muscles, the most active parts of the body, and therefore, in all probability, requiring the most frequent supply. Nor can it be doubted that it is employed for other useful purposes. The quantity of fibrina in the blood, then, must be constantly diminishing, and therefore new fibrina must be constantly formed. But the only substances out of which it can be formed are the chyle and lymph, neither of which contain it. There must therefore be a continual decomposition of the chyle and lymph going on in the blood-vessels, and a continual new formation of fibrina. Other substances also may be formed; but we are certain that this *must* be formed there, because it does not exist previously. Now, one great end of respiration must undoubtedly be to assist this decomposition of chyle and complete formation of blood.

It follows, from the experiments of Fourcroy formerly enumerated, that fibrina contains more azot, and less hydrogen and carbon, than any of the other ingredients of the blood, and consequently also than any of the ingredients of the chyle. In what manner the chyle, or a part of it, is converted into fibrina, it is impossible to say: we are not sufficiently acquainted with the subject to be able to explain the process. But we can see at least, that carbon and hydrogen must be abstracted from that part of the chyle which is to be converted into fibrina: And we know, that these substances are actually thrown out by respiration. We may conclude, then, that *one* use of the oxygen absorbed is, to abstract a quantity of carbon and hydrogen from a part of the chyle by compound affinity, in such proportions, that the remainder becomes fibrina: therefore one end of respiration is to form fibrina. Doubtless the other ingredients of the blood are also new modified, though we know too little of the subject to throw any light upon it.

512 Produces animal heat;

13. But the complete formation of blood is not the only advantage gained by respiration: the *temperature* of all animals depends upon it. It has been long known, that those animals which do not breathe have a temperature but very little superior to the medium in which they live. This is the case with fishes and many insects. Man, on the contrary, and quadrupeds which breathe, have a temperature considerably higher than the atmosphere: that of man is 98°. Birds, who breathe in proportion a still greater quantity of air than man, have a temperature equal to 103° or 104°. It has been proved, that the temperature of all animals is proportional to the quantity of air which they breathe in a given time.

These facts are sufficient to demonstrate, that the heat of animals depends upon respiration. But it was not till Dr Black's doctrine of latent heat became known to the world, that any explanation of the cause of the temperature of breathing animals was attempted. That illustrious philosopher, whose discoveries form the basis upon which all the scientific part of chemistry has been reared, saw at once the light which his doctrine of latent heat threw upon this part of physiology, and he applied it very early to explain the temperature of animals.

According to him, part of the latent heat of the air inspired becomes sensible; and of course, the temperature of the lungs, and the blood that passes through them, must be raised; and the blood, thus heated, communicates its heat to the whole body. This opinion was ingenious, but it was liable to an unanswerable objection: for if it were true, the temperature of the body ought to be greatest in the lungs, and to diminish gradually as the distance from the lungs increases; which is not true. The theory, in consequence, was abandoned even by Dr Black himself; at least he made no attempt to support it.

Lavoisier and Crawford, who considered all the changes operated by respiration as taking place in the lungs, accounted for the origin of the animal heat almost precisely in the same manner with Dr Black. According to them, the oxygen gas of the air combines in the lungs with the hydrogen and carbon emitted by the blood. During this combination, the oxygen gives out a great quantity of caloric, with which it had been combined; and this caloric is not only sufficient to support the temperature of the body, but also to carry off the new formed water in the state of vapour, and to raise considerably the temperature of the air inspired. According to these philosophers, then, the whole of the caloric which supports the temperature of the body is evolved in the lungs. Their theory accordingly was liable to the same objection with Dr Black's; but they obviated it in the following manner: Dr Crawford found, that the specific caloric of arterial blood was 1,0300, while that of veinous blood was only 0,8928. Hence he concluded, that [illegible] veinous blood is changed into arterial [illegible] consequently it [illegible] quantity of caloric to keep its [illegible] veinous blood. [illegible] the whole new caloric [illegible] employed; therefore the temperature of the [illegible] remain the same as that of the [illegible] the circulation, arterial blood is [illegible] consequently its specific [illegible] give out heat. This [illegible] of the extreme parts [illegible] diminish.

This explanation [illegible] ingenious, but it is not q[illegible] difference in the specific caloric, granting it to be accurate, is too small to account for the great quantity of heat which must be evolved. It is evident that it must fall to the ground altogether, provided, as we have seen reason to suppose, the carbonic acid gas and water be not formed in the lungs, but during the circulation.

Since the oxygen enters the blood, and combines with it in the state of gas, it is evident that it will only part at first with some of its caloric; and this portion is chiefly employed in carrying off the carbonic acid gas and the water. For the reason that the carbonic acid leaves the blood at the instant that the oxygen gas enters it, seems to be this: The oxygen gas combines with the blood, and part of its caloric unites at the same instant to the carbonic acid, and converts it into gas: another portion converts the water into vapour. The rest of the caloric is evolved during the circulation when the oxygen combines with hydrogen and carbon, and forms water and carbonic acid gas. The quantity of caloric evolved in the lungs seems not only sufficient to carry off the carbonic acid and water, which the diminution

Functions of Animals. nution of the specific caloric (if it really take place) must facilitate; but it seems also to raise the temperature of the blood a little higher than it was before. For Mr John Hunter constantly found, that the heat of the heart in animals was a degree higher than any other part of the body which he examined. Now this could scarcely happen, unless the temperature of the blood were somewhat raised during respiration.

353 And supports the circulation. Thus we have seen two uses which respiration seems to serve. The first is the completion of blood by the formation of fibrina; the second is the maintaining of the temperature of the body at a particular standard, notwithstanding the heat which it is continually giving out to the colder surrounding bodies. But there is a third purpose, which explains why the animal is killed so suddenly when respiration is stopped. The circulation of the blood is absolutely necessary for the continuance of life. Now the blood is circulated in a great measure by the alternate contractions of the heart. It is necessary that the heart should contract regularly, otherwise the circulation could not go on. But the heart is stimulated to contract by the blood: and, unless blood be made to undergo the change produced by respiration, it ceases almost instantaneously to stimulate. As the blood receives oxygen in the lungs, we may conclude that the presence of oxygen is necessary to its stimulating power *.

* Girtanner, Jour. de Phys. xxxix.

354 Kidneys employed in the formation of blood. 14. Thus we have reason to suppose, that chyle and lymph are converted into blood during the circulation; and that the oxygen gas supplied by respiration is one of the principal agents in this change. But besides the lungs and arteries, there is another organ, the sole use of which is also to produce some change or other in the blood, which renders it more complete, and more proper for the various purposes to which it is applied. This organ is the *kidney*.

For the structure of the kidneys, which in man and quadrupeds are two in number, we refer to ANATOMY, *Index*. A very great proportion of blood passes thro' them; indeed, we have every reason to conclude, that the whole of the blood passes through them very frequently.

These organs separate the urine from the blood, to be afterwards evacuated without being applied to any purpose useful to the animal.

The kidneys are absolutely necessary for the continuance of the life of the animal; for it dies very speedily when they become by disease unfit to perform their functions: therefore the change which they produce in the blood is a change necessary for qualifying it to answer the purposes for which it is intended.

As the urine is immediately excreted, it is evident that the change which the kidneys perform is intended solely for the sake of the blood. It is not merely the abstraction of a quantity of water and of salts, accumulated in the blood, which the kidney performs. A chemical change is certainly produced, either upon the whole blood, or at least on some important part of it; for there are two substances found in the urine which do not exist in the blood. These two substances are urea and uric acid. They are formed, therefore, in the kidneys; and as they are thrown out, after being formed, without being applied to any useful purpose, they are certainly not formed in the kidneys for their own sake. Some part of the blood, then, must be decomposed in the kidney, and a new substance, or new substances, must be formed; and the ur [illegible] id must be formed at the same time, in consequence of the combined action of the affinities which [illegible] uce the change on the blood; and being useless, they are thrown out, together with a quantity of water and salts, which, in all probability, were useful in bringing about the changes which take place in the arteries and in the kidneys, but which are no longer of any service after these changes are brought about.

The changes operated upon the blood in the kidneys are hitherto altogether unknown; but they must be important.

355 Cutaneous vessels. Provided the method of analysing animal substances were so far perfected as to admit of accurate conclusions, considerable light might be thrown upon this subject, by analysing with care a portion of blood from the emulgent vein and artery separately, and ascertaining precisely in what particulars they differ from each other.

15. Thus we have seen that the principal changes which the blood undergoes, as far at least as we are at present acquainted with them, take place in the lungs, in the kidneys, and in the arteries. In the lungs, a quantity of water and carbonic acid gas is emitted from the blood, and in the kidney the urine is formed and separated from it. There seems also to be something thrown out from the blood during its circulation in the arteries, at least through those vessels which are near the surface of the body: For it is a fact, that certain substances are constantly emitted from the skins of animals. These substances are known in general by the name of *perspirable matter*, or *perspiration*. They have a great resemblance to what is emitted in the lungs; which renders it probable, that they are both owing to the same cause; namely, to the decomposition produced in the blood by the effects of respiration. They consist chiefly of water in a state of vapour, carbon, and oil.

356 Emit aqueous vapour. The quantity of aqueous vapour differs very considerably, according to circumstances. It has been shewn to be greatest in hot weather, and in hot climates, and after great exercise; and its relation to the quantity of urine has been long known. When the aqueous vapour perspired is great, the quantity of urine is small, and *vice versa*.

The most accurate experiments on this matter that we have seen are those of Mr Cruikshank. He put his hand into a glass vessel, and luted its mouth at his wrist by means of a bladder. The interior surface of the vessel became gradually dim, and drops of water trickled down. By keeping his hand in this manner for an hour, he collected 30 grains of a liquid, which possessed all the properties of pure water *. On repeating the same experiment at nine in the evening (thermometer 62°), he collected only 12 grains. The mean of these is 21 grains. But as the hand is more exposed than the trunk of the body, it is reasonable to suppose that the perspiration from it is greater than that from the hand. Let us therefore take 30 grains per hour as the mean; and let us suppose, with Mr Cruikshank, that the hand is $\frac{1}{60}$th of the surface of the body. The perspiration in an hour would amount to 1800 grains, and in 24 hours to 43200 grains, or 7 pounds 6 ounces troy.

* On Insensible Perspiration, p. 68.

He

He repeated the experiment again after hard exercise, and collected in an hour 48 grains of water*. He found also, that this aqueous vapour pervaded his stocking without difficulty; and that it made its way thro' a shamoy leather glove, and even through a leather boot, though in much smaller quantity than when the leg wanted that covering†.

* On Insensible Perspiration, p. 7..

† Ibid p. 82.

It is not difficult to see why the quantity of watery vapour diminishes with cold. When the surface of the body is exposed to a cold temperature, the capacity of the cutaneous vessels diminishes, and consequently the quantity which flows through them must decrease

When the temperature, on the other hand, is much increased, either by being exposed to a hot atmosphere, or by violent exercise, the perspired vapour not only increases in quantity, but even appears in a liquid form. This is known by the name of *sweat*. In what manner sweat is produced, is not at present known; but we can see a very important service which it performs to the animal.

No sooner is it thrown upon the surface of the skin than it begins to evaporate. But the change into vapour requires heat; accordingly a quantity of heat is absorbed, and the temperature of the animal is lowered. This is the reason that animals can endure to remain for some time in a much higher temperature without injury than could have been supposed.

The experiments of Tillet, and the still more decisive experiments of Fordyce and his associates, are well known. These gentlemen remained a considerable time in a temperature exceeding the boiling point of water.

357 Carbon, Besides water, it cannot be doubted that *carbon* is also emitted from the skin; but in what state, the experiments hitherto made do not enable us to decide. Mr Cruikshank found, that the air of the glass vessel in which his hand and foot had been confined for an hour, contained carbonic acid gas; for a candle burned dimly in it, and it rendered lime-water turbid*. And Mr Jurine found, that air which had remained for some time in contact with the skin, consisted almost entirely of carbonic acid gas†. The same conclusion may be drawn from the experiments of Ingenhousz and Milly‡.

* Ibid. p. 70 and 81

† Enc. Meth. Med. i. p. 515.

‡ Ibid. p. 511.

Now it is evident, that the carbonic acid gas which appeared during Mr Cruikshank's experiment, did not previously exist in the glass vessel; consequently it must have either been transmitted ready formed through the skin, or formed during the experiment by the absorption of oxygen gas, and the consequent emission of carbonic acid gas. The experiments of Mr Jurine do not allow us to suppose the first of these to be true; for he found, that the quantity of air allowed to remain in contact with the skin did not increase. Consequently the appearance of the carbonic acid gas must be owing, either to the emission of carbon, which forms carbonic acid gas by combining with the oxygen gas of the air, or to the absorption of oxygen gas, and the subsequent emission of carbonic acid gas, precisely in the same manner, and for the same reason, that these substances are emitted by the lungs. The last is the more probable opinion; but the experiments hitherto made do not enable us to decide.

358 And an oily matter. Besides water and carbon, or carbonic acid gas, the skin emits also a particular odorous substance. That every animal has a peculiar smell, is well known: the dog can discover his master, and even trace him to a distance by the scent. A dog, chained some hours after his master had set out on a journey of some hundred miles, followed his footsteps by the smell, and found him on the third day in the midst of a crowd*. But it is needless to multiply instances of this fact; they are too well known to every one. Now this smell must be owing to some peculiar matter which is constantly emitted; and this matter must differ somewhat either in quantity or some other property, as we see that the dog easily distinguishes the individual by means of it. Mr Cruikshank has made it probable that this matter is an oily substance; or at least that there is an oily substance emitted by the skin. He wore repeatedly, night and day for a month, the same vest of fleecy hosiery during the hottest part of the summer. At the end of this time he always found an oily substance accumulated in considerable masses on the nap of the inner surface of the vest, in the form of black tears. When rubbed on paper, it makes it transparent, and hardens on it like grease. It burns with a white flame, and leaves behind it a charry residuum†.

* Cruikshank, ibid. p. 93.

† Ibid. p. 91.

It has been supposed that the skin has the property of *absorbing moisture* from the air; but this opinion has not been confirmed by experiments, but rather the contrary.

359 Whether the skin absorbs moisture, The chief arguments in favour of the absorption of the skin, have been drawn from the quantity of moisture discharged by urine being, in some cases, not only greater than the whole drink of the patient, but even than the whole of his drink and food. But it ought to be remembered that, in diabetes, the disease here alluded to, the weight of the body is continually diminishing, and therefore part of it must be constantly thrown off. Besides, it is scarcely possible in that disease to get an accurate account of the food swallowed by the patients; and in those cases where very accurate accounts have been kept, and where deception was not so much practised, the urine was found not to exceed the quantity of drink*. In a case of diabetes, related with much accuracy by Dr Gerard, the patient was bathed regularly during the early part of the disease in warm water, and afterwards in cold water: he was weighed before and after bathing, and no sensible difference was ever found in his weight†. Consequently, in that case, the quantity absorbed, if any, must have been very small.

* See Rollo on Diabetes.

† Ibid. ii. 73.

It is well known, that thirst is much alleviated by cold bathing. By this plan, Captain Bligh kept his men cool and in good health during their very extraordinary voyage across the South Sea. This has been considered as owing to the absorption of water by the skin. But Dr Currie had a patient who was wasting fast for want of nourishment, a tumor in the œsophagus preventing the possibility of taking food, and whose thirst was always alleviated by bathing; yet no sensible increase of weight, but rather the contrary, was perceived after bathing. It does not appear, then, that in either of these cases water was absorbed.

Farther, Seguin has shewn that the skin does not absorb water during bathing, by a still more complete experiment: He dissolved some mercurial salt in water, and found that the mercury produced no effect upon a person that bathed in the water, provided no part of the

the cuticle was injured; but upon rubbing off a portion of the cuticle, the mercurial ſolution was abſorbed, and the effects of the mercury became evident upon the body. Hence it follows irreſiſtibly, that water, at leaſt in the ſtate of *water*, is not abſorbed by the ſkin when the body is plunged into it, unleſs the cuticle be firſt removed.

360 Or any other ſub. This may perhaps be conſidered as a complete proof that no ſuch thing as abſorption is performed by the ſkin; and that therefore the appearance of carbonic acid gas, which takes place when air is confined around the ſkin, muſt be owing to the emiſſion of carbon. But it ought to be conſidered, that although the ſkin cannot abſorb water, this is no proof that it cannot abſorb other ſubſtances; particularly, that it cannot abſorb oxygen gas, which is very different from water. It is well known, that water will not paſs through bladders, at leaſt for ſome time; yet Dr Prieſtley found that veinous blood acquired the colour of arterial blood from oxygen gas, as readily when theſe ſubſtances were ſeparated by a bladder as when they were in actual contact. He found, too, that when gaſes were confined in bladders, they gradually loſt their properties. It is clear from theſe facts, that oxygen gas can pervade bladders; and if it can pervade them, why may it not alſo pervade the cuticle? Nay, farther, we know from the experiments of Cruikſhank, that the vapour perſpired paſſes through leather, even when prepared ſo as to keep out moiſture, at leaſt for a certain time. It is poſſible, then, that water, when in the ſtate of vapour, or when diſſolved in air, may be abſorbed, although water, while in the ſtate of water, may be incapable of pervading the cuticle. The experiments, then, which have hitherto at leaſt been made upon the abſorption of the ſkin, are altogether inſufficient to prove that air and vapour cannot pervade the cuticle; provided at leaſt there be any facts to render the contrary ſuppoſition probable.

Now that there are ſuch facts cannot be denied. We ſhall not indeed produce the experiment of Van Mons as a fact of that kind, becauſe it is liable to objections, and at beſt is very undeciſive. Having a patient under his care who, from a wound in the throat, was incapable for ſeveral days of taking any nouriſhment, he kept him alive during that time, by applying to the ſkin in different parts of the body, ſeveral times a day, a ſponge dipt in wine or ſtrong ſoup *. A fact mentioned by Dr Watſon is much more important, and much more deciſive. A lad at Newmarket, who had been almoſt ſtarved in order to bring him down to ſuch a weight as would qualify him for running a horſe race, was weighed in the morning of the race day; he was weighed again juſt before the race began, and was found to have gained 30 ounces of weight ſince the morning; yet in the interval he had only taken a ſingle glaſs of wine. Here abſorption muſt have taken place, either by the ſkin, or lungs, or both. The difficulties in either caſe are the ſame; and whatever renders abſorption by one probable, will equally ſtrengthen the probability that abſorption takes place by the other (R).

16. We have now ſeen the proceſs of digeſtion, and the formation of blood, as far at leaſt as we are acquainted with it. But to what purpoſes is this blood employed, which is formed with ſo much care, and for the formation of which ſo great an apparatus has been provided? It anſwers two purpoſes. The parts of which the body is compoſed, bones, muſcles, ligaments, membranes, &c. are continually changing. In youth they are increaſing in ſize and ſtrength, and in mature age they are continually acting, and conſequently continually liable to waſte and decay. They are often expoſed to accidents, which render them unfit for performing their various functions; and even when no ſuch accident happens, it ſeems neceſſary for the health of the ſyſtem that they ſhould be every now and then renewed. Materials therefore muſt be provided for repairing, increaſing, or renewing all the various organs of the body. Phoſphat of lime and gelatine for the bones, fibrina for the muſcles, albumen for the cartilages and membranes, &c. Accordingly all theſe ſubſtances are laid up in the blood; and they are drawn from that fluid as from a ſtorehouſe whenever they are required. The proceſs by which the different parts of the blood are made part of the various organs of the body is called *aſſimilation*. 361 Blood ſupplies the waſte of the ſyſtem.

362 Aſſimilation. Over the nature of aſſimilation the thickeſt darkneſs ſtill hangs; there is no key to explain it, nothing to lead us to the knowledge of the inſtruments employed. Facts, however, have been accumulated in ſufficient numbers to put the exiſtence of the proceſs beyond the reach of doubt. The healing, indeed, of every fractured bone, and every wound of the body, is a proof of its exiſtence, and an inſtance of its action.

363 Every aſſimilating organ produces a peculiar change, Every organ employed in aſſimilation has a peculiar office; and it always performs this office whenever it has materials to act upon, even when the performance of it is contrary to the intereſt of the animal. Thus the ſtomach always converts food into chyme, even when the food is of ſuch a nature that the proceſs of digeſtion will be retarded rather than promoted by the change. If warm milk, for inſtance, or warm blood, be thrown into the ſtomach, they are always decompoſed by that organ, and converted into chyme; yet theſe ſubſtances are much more nearly aſſimilated to the animal before the action of the ſtomach than after it. The ſame thing happens when we eat animal food.

364 And no other change. On the other hand, a ſubſtance introduced into an organ employed in aſſimilation, if it has undergone preciſely the change which that organ is fitted to produce, is not acted upon by that organ, but paſſed on unaltered to the next aſſimilating organ. Thus it is the office of the inteſtines to convert chyme into chyle. Accordingly, whenever chyme is introduced into the inteſtines, they perform their office, and produce the uſual change; but if chyle itſelf be introduced into the inteſtines, it is abſorbed by the lacteals without alteration. The experiment, indeed, has not been tried with true chyle, becauſe it is ſcarce poſſible to procure it in ſufficient quantity; but when milk, which reſembles chyle pretty accurately, is thrown into the jejunum, it is abſorbed unchanged by the lacteals *.

* Fordyce on Digeſtion, p. 159.

Again,

(R) The Abbé Fontana alſo found, that after walking in moiſt air for an hour or two, he returned home ſome ounces heavier than he went out, notwithſtanding he had ſuffered conſiderable evacuation from a briſk purge purpoſely taken for the experiment. This increaſe, indeed, might be partly accounted for by the abſorption of moiſture by his clothes.

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Again, the office of the blood vessels, as assimilating organs, is to convert chyle into blood. Chyle, accordingly, cannot be introduced into the arteries without undergoing that change; but *blood* may be introduced from another animal without any injury, and consequently without undergoing any change. This experiment was first made by Lower, and it has since been very often repeated.

Also, if a piece of fresh muscular flesh be applied to the muscle of an animal, they adhere and incorporate without any change, as has been sufficiently established by the experiments of Mr J. Hunter. And Buvina has ascertained, that fresh bone may, in the same manner, be engrafted on the bones of animals of the same or of different species †.

† *Phil. Mag.* vi. 308.

In short, it seems to hold, at least as far as experiments have hitherto been made, that foreign substances may be incorporated with those of the body, provided they be precisely of the same kind with those to which they are added, whether fluid or solid. Thus chyle may be mixed with chyle, blood with blood, muscle with muscle, and bone with bone. The experiment has not been extended to the other animal substances, the nerves, for instance; but it is extremely probable that it would hold with respect to them also.

On the other hand, when substances are introduced into any part of the body which are not the same with that part, nor the same with the substance upon which that part acts; provided they cannot be thrown out readily, they destroy the part, and perhaps even the animal. Thus foreign substances introduced into the blood very soon prove fatal; and introduced into wounds of the flesh or bones, they prevent these parts from healing.

365 Their power limited.

Although the different assimilating organs have the power of changing certain substances into others, and of throwing out the useless ingredients, yet this power is not absolute, even when the substances on which they act are proper for undergoing the change which the organs produce. Thus the stomach converts food into chyme, the intestines chyme into chyle, and the substances which have not been converted into chyle are thrown out of the body. If there happen to be present in the stomach and intestines any substance which, though incapable of undergoing the changes, at least, by the action of the stomach and intestines, yet has a strong affinity, either for the whole chyme and chyle, or for some particular part of it, and no affinity for the substances which are thrown out, that substance passes along with the chyle, and in many cases continues to remain chemically combined with the substance to which it is united in the stomach, even after that substance has been completely assimilated, and made a part of the body of the animal. Thus there is a strong affinity between the colouring matter of madder and phosphat of lime. Accordingly, when madder is taken into the stomach, it combines with the phosphat of lime of the food, passes with it through the lacteals and blood vessels, and is deposited with it in the bones, as was proved by the experiments of Duhamel. In the same manner musk, indigo, &c. when taken into the stomach, make their way into many of the secretions.

These facts shew us, that assimilation is a chemical process from beginning to end; that all the changes are produced according to the laws of chemistry; and that we can even derange the regularity of the process by introducing substances whose mutual affinities are too strong for the organs to overcome.

366 Assimilation a chemical process;

It cannot be denied, then, that the assimilation of food consists merely in a certain number of chemical decompositions which that food undergoes, and the consequent formation of certain new compounds. But are the *agents* employed in assimilation merely chemical agents? We cannot produce any thing like these changes on the food out of the body, and therefore we must allow that they are the consequence of the action of the animal organs. But this action, it may be said, is merely the secretion of particular juices, which have the property of inducing the wished for change upon the food; and this very change would be produced out of the body, provided we could procure these substances, and apply them in proper quantity to the food. If this supposition be true, the specific action of the vessels consists in the secretion of certain substances; consequently the cause of this secretion is the *real* agent in assimilation. Now, can the *cause* of this secretion be shewn to be merely a chemical agent? Certainly not. For in the stomach, where only this secretion can be shewn to exist, it is not always the same, but varies according to circumstances. Thus eagles at first cannot digest grain, but they may be brought to do it by persisting in making them use it as food. On the contrary, a lamb cannot at first digest animal food, but habit will also give it this power. In this case, it is evident that the gastric juice changes according to circumstances. Now this is so far from being a case of a chemical law, that it is absolutely incompatible with every such law. The agent in assimilation, then, is not a chemical agent, but one which acts upon different principles. It is true, indeed, that every [illegible] the process is chemical; but the agent which [illegible] these chemical processes, which prevents them [illegible]g, except in particular circumstances and on [illegible] substances, and modifies this action according [illegible]stances, is not a mere chemical agent, but endowed [illegible] very different properties.

367 But the agent not chemical.

The presence and power of [illegible]nt will be still more evident, if we consider [illegible]ity of the stomach of the living animal during the process of digestion. The stomach of animals is as fit for food as any other substance. The gastric juice, therefore, must have the same power of acting on it, and of decomposing it, that it has of acting on other substances; yet it is well known that the stomach is not affected by digestion while the animal retains life; though, as Mr Hunter ascertained, the very gastric juice which the living stomach secretes often dissolves the stomach itself after death. Now what is the power which prevents the gastric juice from acting on the stomach during life? Certainly neither a chemical nor mechanical agent, for these agents must still retain the same power after death. We must, then, of necessity conclude, that there exists in the animal an agent very different from chemical and mechanical powers, since it controuls these powers according to its pleasure. These powers therefore in the living body are merely the servants of this superior agent, which directs them so as to accomplish always one particular end. This agent seems to regulate the chemical powers, chiefly by bringing only certain substances together which are to be decomposed, and by keeping at a distance those substances which would interfere with, or diminish, or spoil the product, or

injure

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injure the organ. And we see that this separation is always attended to even when the substances are apparently mixed together. For the very same products are not obtained which would be obtained by mixing the same substances together out of the body that are produced by mixing them in the body; consequently all the substances are not left at full liberty to obey the laws of their mutual affinities. The superior agent, however, is not able to exercise an unlimited authority over the chemical powers; sometimes they are too strong for it: some substances accordingly, as madder, make their way into the system; while others, as arsenic, decompose and destroy the organs of the body themselves.

But it is not in digestion alone that this superior agent makes the most wonderful display of its power; it is in the last part of assimilation that our admiration is most powerfully excited. How comes it that the precise substances wanted are always carried to every organ of the body? How comes it that fibrina is always regularly deposited in the muscles, and phosphat of lime in the bones? And what is still more unaccountable, how comes it that prodigious quantities of some one particular substance are formed and carried to a particular place in order to supply new wants which did not before exist? A bone, for example, becomes diseased and unfit for the use of the animal; a new bone therefore is formed in its place, and the old one is carried off by the absorbents. In order to form this new bone, large quantities of phosphat of lime are deposited in a place where the same quantity was not before necessary. Now, who informs this agent that an unusual quantity of phosphat of lime is necessary, and that it must be carried to that particular place? Or granting, as is most probable, that the phosphat of lime of the old bone is partly employed for this purpose, who taught this agent that the old bone must be carried off, new modelled, and deposited, and assimilated anew? The same wonders take place during the healing of every wound, and the renewing of every diseased part.

These operations are incompatible with the supposition that the body of animals is a mere chemical and mechanical machine; and demonstrate the presence of some agent besides, which acts according to very different laws.

But neither in this case is the power of this agent over the chemical agents, which are employed, absolute. We may prevent a fractured bone from healing by giving the patient large quantities of acids. And unless the materials for the new wanted substances be supplied by the food, they cannot, in many cases, be formed at all. Thus the canary bird cannot complete her eggs unless she be furnished with lime.

It is evident that the supreme agent of the animal body, whatever that agent may be, acts according to fixed laws; and that when these laws are opposed by those which are more powerful, it cannot overcome them. These laws clearly indicate design; and the agent has the power of modifying them somewhat according to circumstances. Thus more phosphat of lime is sent to a limb which requires a new bone, and more lime than usual is taken into the system when the hen is laying eggs. Design and contingency are considered by us as infallible marks of consciousness and intelligence. That they are infallible marks of the agency of mind is certain; but that they are in all cases the proofs of immediate consciousness and intelligence, as the Stahlians supposed, cannot be affirmed without running into inconsistencies. For we ourselves are not conscious of those operations which take place during *assimilation*.

To say that a being can act with design without intelligence, we allow to be a flat contradiction, because design always implies intelligence. There must therefore be intelligence somewhere. But may not this intelligence exist, not in the agent, but in the being who formed the agent? And may not the whole of the design belong in reality to that being?

368 Not matter.

May not this agent, then, be material, and may not the whole of assimilation be performed by mere matter, acting according to laws given it by its maker? We answer, that what is called *matter*, or the substances enumerated in the first part of CHEMISTRY (*Suppl.*) act always according to certain attractions and repulsions, which are known by the name of mechanical and chemical laws.

The phenomena of assimilation are so far from being cases of these laws, that they are absolutely inconsistent with them, and contrary to them; consequently the agent which presides over *assimilation* is not *matter*. Concerning the nature of this substance it is not the business of this article to inquire; but as it possesses properties different from matter, and acts according to very different laws, it would be an abuse of terms to call it *matter*.

369 Animal principle.

We would give it the name of *mind*, were it not that metaphysicians have chosen to consider intelligence as the essence of mind; whereas this substance may be conceived to act, and really does act, without intelligence. There is no reason, however, to suppose, with some, that there are two substances in animals: one possessed of consciousness as its essence, and therefore called *mind* or *soul* in man; another, destitute of conciousness, called the *living principle*, &c. employed in performing the different functions of assimilation, absorption, &c. It is much more reasonable to suppose, that in every animal and vegetable there is a peculiar substance, different from matter, to which their peculiar properties are owing; that this substance is different in every species of animal and vegetable; that it is capable of acting according to certain fixed laws which have been imposed upon it by its Creator, and that these laws are of such a nature that it acts in subservience to a particular end; that this substance in plants is probably destitute of intelligence; that in man and other animals it possesses intelligence to a certain extent, but that this intelligence is not essential to its existence nor to its activity; that it may be deprived of intelligence altogether, and afterwards recover it without altering its nature. Physiologists have given it the name of *living principle*, because its presence constitutes life. Perhaps it would be proper to distinguish that of animals by the name of *animal principle*. Upon what the intelligence of the animal principle depends, it is impossible to say; but it is evidently connected with the state of the brain. During a trance, or an apoplectic fit, it has often been lost for a time, and afterwards recovered.

370 Secretion.

17. Besides assimilation, the blood is also employed in forming all the different secretions which are necessary for the purposes of the animal economy. These have been enumerated in the last chapter. The process is similar to that of assimilation, and undoubtedly the agents in both cases are the same; but we are equally

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equally ignorant of the precise manner in which secretion is performed as we are of assimilation.

18. After these functions have gone on for a certain time, which is longer or shorter according to the nature of the animal, the body gradually decays, at last all its

Animals at length die and why.

functions cease completely, and the animal dies. The cause of this must appear very extraordinary, when we consider the power which the animal has of renewing decayed parts; for it cannot be doubted that death proceeds, in most cases at least, from the body becoming incapable of performing its function. But if we consider that this power is limited, and that it must cease altogether, when those parts of the system begin to decay which are employed in preparing materials for future assimilation, our surprise will, in some measure, cease. It is in these parts, in the organs of digestion and assimilation accordingly, that this decay usually proves fatal. The decay in other parts destroys life only when the waste is so rapid that it does not admit of repair.

What the reason is that the decay of the organs causes death, or, which is the same thing, causes the living principle either to cease to act, or to leave the body altogether, it is perfectly impossible to say, because we know too little of the nature of the living principle, and of the manner in which it is connected with the body. The last is evidently above the human understanding, but many of the properties of the living principle have been discovered; and were the facts already known properly arranged, and such general conclusions drawn from them as their connection with each other fully warrant, a degree of light would be thrown upon the animal economy which those, who have not attended to the subject, are not aware of.

No sooner is the animal dead, than the chemical and mechanical agents, which were formerly servants, usurp the supreme power, and soon decompose and destroy that very body which had been in a great measure reared by their means. But the changes which take place upon animal bodies after death, are too important, and too intimately connected with the subject of this article to be passed over slightly. They shall therefore form the subject of the next chapter.

Chap. IV. Of the Decomposition of Animal Substances.

372 Decomposition of animal substances exposed to the air.

All the soft and the liquid parts of animals, when exposed to a moderate temperature of sixty-five degrees or more, pass with more or less rapidity through the following changes. Their colour becomes paler, and their consistence diminishes; if it be a solid part, such as flesh, it softens, and a serous matter sweats out, whose colour quickly changes; the texture of the part becomes relaxed, and its organization destroyed; it acquires a faint disagreeable smell; the substance gradually sinks down, and is diminished in bulk; its smell becomes stronger and ammoniacal. If the subject be contained in a close vessel, the progress of putrefaction, at this stage, seems to slacken; no other smell but that of a pungent alkali is perceived; the matter effervesces with acids, and converts syrup of violets to a green. But if the communication with the air be admitted, the urinous exhalation is dissipated, and a peculiar putrid smell is spread around with a kind of impetuosity; a smell of the most insupportable kind, which lasts a long time, and pervades every place, affecting the bodies of living animals after the manner of a ferment, capable of altering the fluids: this smell is corrected, and as it were confined by ammonia. When the latter is volatilized, the putrefactive process becomes active a second time, and the substance suddenly swells up, becomes filled with bubbles of air, and soon after subsides again. Its colour changes, the fibrous texture of the flesh being then scarcely distinguishable; and the whole is changed into a soft, brown, or greenish matter, of the consistence of a poultice, whose smell is faint, nauseous, and very active on the bodies of animals. The odorant principle gradually loses its force; the fluid portion of the flesh assumes a kind of consistence, its colour becomes deeper, and it is finally reduced into a friable matter, rather deliquescent, which being rubbed between the fingers, breaks into a coarse powder like earth. This is the last state observed in the putrefaction of animal substances; they do not arrive at this term but at the end of a considerable time †.

† Fourcroy.

373 Buried in the earth.

In carcases buried in the earth, putrefaction takes place much more slowly; but it is scarcely possible to observe its progress with accuracy. The abdomen is gradually dilated with elastic fluids which make their appearance in it, and at last it bursts and discharges a horribly fetid and noxious gas; at the same time a dark coloured liquid flows out. If the earth be very dry, and the heat considerable, the moisture is often absorbed so rapidly, that the carcase, instead of putrefying, dries, and is transformed into what is called a *mummy*.

374 When accumulated together,

Such are the phenomena when dead bodies are left to putrefy separately. But when great numbers of carcases are crowded together in one place, and are so abundant as to exclude the action of external air, and other foreign agents, their decomposition is entirely the consequence of the reciprocal action of their ingredients themselves upon each other, and the result is very different. The body is not entirely dissipated or converted into mould, but all the soft parts are found diminished remarkably in size, and converted into a peculiar *saponaceous matter*. This singular change was first accurately observed in the year 1786.

375 Converted into a saponaceous matter.

The burial ground of the Innocents in Paris having become noxious to those who lived in its neighbourhood, on account of the disagreeable and hurtful odour which it exhaled, it was found necessary to remove the carcases to another place. It had been usual to dig very large pits in that burial ground, and to fill them with the carcases of the poorer sort of people, each in its proper bier; and when they were quite full, to cover them with about a foot depth of earth, and to dig another similar pit, and fill it in the same manner. Each pit held between 1000 and 1500 dead bodies. It was in removing the bodies from these pits that this saponaceous substance was found. The grave-diggers had ascertained, by long experience, that about thirty years were required before all the bodies had undergone this change in its full extent *. Every part of the body acquired the properties of this substance. The intestines and viscera of the thorax had completely disappeared; but what is singular enough, the brain had lost but little of its size or appearance, though it was also converted into the same substance.

* Fourcroy, Ann. de Chim. v. 154.

376 Its properties.

This saponaceous matter was of a white colour, soft and unctuous to the touch, and melted, when heated, like

like tallow. It exhibited all the properties of a *foap*, containing, however, an excefs of fatty matter. Fourcroy, who analyfed it, found that it was compofed of a fatty matter combined with ammonia, and that it contained alfo fome phofphat of lime and ammonia. Diluted acids decompofed it, and feparated the fatty matter: alkalies and lime, on the other hand, drove off the ammonia. When expofed to the air, it gradually loft its white colour; the ammonia, in a great meafure, evaporated, and what remained had fomething of the appearance of wax. It abforbed water with great avidity, and did not part with it readily. Its white colour was owing to the prefence of that liquid. The oily matter, when feparated by means of a diluted acid, was concrete, and of a white colour, owing to the mixture of a quantity of water. When dried, it acquires a greyifh brown colour, a lamellar and cryftalline texture, like that of fpermaceti; but if it has been rapidly dried it affumes the appearance of wax It melts, when heated, to 126°; when properly purified, by paffing it through a linen cloth while fluid, it has fcarcely any fmell. Alcohol does not act upon it while cold, but at the temperature of 120° it diffolves it: when the folution cools, the fatty matter precipitates, and forms a gritty mafs. With alkalies it forms a foap; and when fet on fire it burns precifely like oil or fat, only that it exhales a more unpleafant odour †.

† *Fourcroy, Ann. de Chim.* viii. 17.

377
Produced alfo in running water.

Mr Smith Gibbes found the fame fubftance in the pit into which animal matters are thrown at Oxford after diffection. A fmall ftream of wate[illegible]ly paffes through this pit; a circumftance whic[illegible] him to try whether animal mufcle expofed to the action of a running ftream underwent the fame change. The experiment fucceeded completely: he attempted, in confequence, to render this fubftance, to which he gave the name of *fpermaceti*, ufeful in thofe manufactures which required tallow; but the fetid odour which it conftantly exhales was an infurmountable objection. Attempts were indeed made to get over it; but as we do not hear that Mr Smith Gibbes's fpermaceti has been introduced into any manufacture, we have reafon to conclude that none of thefe attempts fucceeded ‡.

‡ *Phil. Tranf.* 1794 and 1795.

Such are the phenomena of putrefaction, as far as they are at prefent known to chemifts. Any attempt to explain the manner in which thefe changes take place, would be exceedingly imperfect indeed; not only becaufe we are ignorant of the ftrength of the affinities of the different elementary parts of animal bodies for each other, but becaufe we do not even know the manner in which thefe elements are combined, and confequently we cannot know by what particular forces thefe compounds are deftroyed. We know only that a certain degree of heat, and the prefence of moifture, are in all cafes neceffary for the putrefactive procefs; for animal bodies may be kept almoft any length of time, without decompofition, at the freezing temperature; and when dried quickly, and kept in that ftate, they undergo no farther change.

PART III. OF DYEING.

MANKIND have in all periods of fociety manifefted a fondnefs for beautiful and gaudy colours. Naked favages at firft applied them to their fkin. This was the cafe with the Britons, and with the Gauls, too, in the time of Cæfar; it is even ftill the practice in the South Sea iflands, and many parts of America. When mankind had advanced fo far towards civilization as to wear garments, they naturally transferred to them the colours which they admired. Hence the origin of *dyeing*; which is of fuch antiquity, that it precedes the earlieft records left us by profane authors. We fee from the book of Genefis the great progrefs which it had made in the time of the patriarchs.

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Origin of dyeing.

Dyeing feems to have originated in India, and to have fpread gradually from that country to the weft. The Indians were the inventors of the method of dyeing cotton and linen, which was not underftood in Europe before the conquefts of Alexander the Great. The Phenicians excelled in the art at a very early period. It was from them that the Jews purchafed all the dyed ftuffs defcribed in Exodus. The Phenician dyers feem to have confined their art to wool: filk was unknown to them, and linen was ufually worn white. From them the art of dyeing paffed to the Greeks and Romans.

During the fifth century, the Weftern Empire was overturned by the northern nations, and with it the arts and fciences, which had flourifhed under the protection of the Romans, difappeared. A few of the arts, indeed, were preferved in Italy, but they were obfcured and degraded. By degrees, however, a fpirit of induftry began to revive in that country. Florence, Genoa, and Venice, becoming rich commercial cities, carried on a confiderable intercourfe with the Grecian empire, where many of the arts had been preferved. This intercourfe was much increafed by the crufades. The Italian cities became rich and powerful: the arts which diftinguifh civilized nations were cultivated with emulation, and dyeing, among others, was rapidly improved.

380
Its progrefs in modern Europe.

In the year 1429, the firft treatife on dyeing made its appearance at Venice, under the name of *Moriegola dell'arte de tentori*. Giovanne Ventura Rofetta collected, with great induftry, all the proceffes employed by the dyers of his time, and publifhed them in 1548, under the title of *Plictho* *. For many years dyeing was almoft exclufively confined to Italy; but it gradually made its way to France, the Low Countries, and to Britain. The minifter Colbert, who employed his talents in extending the commerce and manufactures of France, paid particular attention to the art of *dyeing*. In the year 1672, he publifhed a table of inftructions, by which thofe who practifed the art were laid under feveral very improper reftrictions. But the bad effects of thefe were in a good meafure obviated by the judicious appointment of men of fcience to fuperintend the art. This plan, begun by Colbert, was continued by the French government. Accordingly, Dufay, Hellot, Macquer, and Berthollet, fucceffively filled the office. It is to this eftablifhment, and to exertions of the celebrated chemifts who have filled it, that France is indebted for the improvements fhe has made in the art of dyeing during the courfe of the 18th century. Under the direction of Dufay, a new table of regulations was publifhed in 1737, which fuperfeded that of Colbert. Hellot,

* *Berthollet on Dyeing*, i. 22.

Substances used for Clothing.

Hellot, his successor, published, in 1740, an excellent system of dyeing wool; and Macquer in 1763 published his treatise on dyeing silk.

In Britain, though dyeing has been carried on for many years with great success, very little progress was made in investigating the theory of the art. The Royal Society, indeed, soon after its institution, recommended it to some of its members; but as no treatise made its appearance in consequence of this, it seems very soon to have lost their attention. Lewis, many years after, published some very important remarks on dyeing; but they were confined to a few processes. The British dyers satisfied themselves with a translation of Hellot. Such was the state of the art when the article DYEING in the *Encyclopædia* was drawn up. It consists chiefly of an abstract of Hellot's treatise. But within the last 30 years, the attention of men of science has been very much turned to this complicated art. In Sweden has appeared the treatise of Scheffer, and Bergman's notes on it; in Germany, the experiments of Beckmann, Poerner, and Vogler, and the dissertation of Francheville; in France, the treatises of D'Ambournay, D'Apligny, Hauffmann, Chaptal, and, above all, of Berthollet; in this country, the ingenious remarks of Delaval, of Henry, and the valuable treatise of Dr Bancroft; besides many other important essays. These, together with the progress of the science of chemistry, on which the theory of dyeing depends, have thrown so much new light upon the art, that we find ourselves under the necessity of tracing the whole over again. We shall pass over, however, very slightly those parts of the art which have been sufficiently explained in the article DYEING, *Encycl.*

To understand the art of *dyeing*, we must be acquainted with the *substances* on which it is practised, with the nature of *colour*, and with the method of permanently changing the colour of bodies. These three things we shall consider in the three following chapters. In the first, we shall give an account of the substances of which garments are usually made, with which alone the art of dyeing is concerned; in the second, we shall inquire into the nature of colour; and in the third, explain the theory of dyeing, as far as it is at present understood. In some subsequent chapters, we shall give a general view of the processes by which the different colours are given to stuffs.

CHAP. I. OF THE SUBSTANCES USED FOR CLOTHING.

381 Clothing

THE substances commonly employed for clothing may be reduced to four; namely *wool*, *silk*, *cotton*, *linen*. As there is no name in the English language which includes all these substances, we shall take the liberty, in the remainder of this article, to use the word *cloth* for that purpose. They are all made into *cloth*, of some kind or other, before they can be useful as articles of *clothing*.

382 Consists of wool,

1. WOOL, as is well known, is the hair which covers the bodies of sheep; it differs from common *hair* merely in fineness and softness. Its filaments possess a considerable degree of elasticity; they may be drawn out beyond their usual length, and afterwards recover their form, when the external force is removed. The surface of wool and hair is by no means smooth: No inequality, indeed, can be perceived by a microscope; nor is any resistance felt when a hair is laid hold of in one hand, and drawn between the fingers of the other, from the *root* towards the *point*; but if it be drawn from the *point* towards the *root*, a resistance is felt which did not take place before, a tremulous motion is perceived, and a noise may be distinguished by the ear. If, after laying hold of a hair between the thumb and fore finger, we rub them against each other in the longitudinal direction of the hair, it acquires a progressive motion *towards the root*; the *point* gradually approaches the fingers, while the *root* recedes from them; so that the whole hair very soon passes through between the fingers.

These observations, first made by Mr Monge, demonstrate that the surface of hair and wool is composed, either of small laminæ, placed over each other in a slanting direction from the root towards the point, like the scales of a fish—or of zones, placed one above another, as takes place in the horns of animals *.

On this structure of the filaments of hair and wool depend the effects of *felting* and *fulling*. In both of these operations, the filaments are made, by an external force, to rub against each other; the position of their asperities prevents them from moving, except in one direction: they are mutually entangled, and obliged to approach nearer each other. Hence the thickness which cloth acquires in the fulling mill. The filaments have undergone a certain degree of felting, and are interwoven like the fibres of a hat. The cloth is contracted both in length and breadth: it may be cut without being subject to ravel; nor is there any necessity for hemming the different pieces employed to make a garment. See FELTING and FULLING, in this *Suppl.*

* Ann. de Chim. vi. 300.

Wool is naturally covered with a kind of grease, which preserves it from moths. This is always removed before the wool is dyed; because its presence is very prejudicial to the success of that operation. The asperities of the surface of woolly fibres would impede the converting of it into thread by spinning; but they are in a great measure covered, previous to that operation, by soaking the wool with oil. The oil must also be removed before the wool be dyed. This process is called SCOURING, which see in this *Suppl.*

We have already, in the second part of this article, given an account of what is at present known concerning the composition of wool and hair. It would be foreign to the subject of this chapter, to describe the method of *spinning* and *weaving* wool.

Wool is of different colours; but that which is white is preferred for making cloth; because it answers better for the purposes of dying than any other kind.

383 Silk,

2. SILK is a substance spun in fine threads by the *silk worm*. Its fibres are not scaly like those of wool; neither have they the same elasticity: but silk, in its natural state, before it has undergone any preparation, has a considerable degree of stiffness and elasticity. In this state it is known by the name of *raw silk*. It is covered with a kind of gummy varnish, which may be removed by scouring with soap. The scouring deprives it of its stiffness and elasticity. Raw silk is of a yellow colour, owing to yellow resinous matter with which it is naturally combined. We have given the method of separating this matter, and also the gum, in the article BLEACHING, *Supplement*.

Silk, before it is dyed, is always freed from its gum, and generally also from its resin. It may be dyed with-

out

Substances [...] out the application of heat; which is not the case with wool.

3. COTTON is a fine downy substance, contained in the pods of different species of gossypium. The species from which the greater part of the cotton brought to this country is taken is the *herbaceum*. The quantity imported annually into Britain is very great; in 1786 it amounted to 20 millions of pounds ‡. Cotton varies greatly, according to the plant on which it grows, and the climate where it is cultivated. The chief differences are in colour, and in the length, fineness, and strength of the filaments.

384 Cotton.

‡ *Bancroft*, i. 69.

No asperities can be discovered on the surface of these filaments; but Lewenhoeck observed, by means of a microscope, that they are triangular, and have three sharp edges. This is probably the reason of a well known fact, that cotton cloth, when applied by way of dressing, always irritates a sore.

Some cottons are naturally white; others a fine light yellow, as those of which nankeen is made; but most commonly cotton is of a dirty brownish yellow colour, which must be removed before the stuff can be dyed. This is done by the process of *bleaching*. The fibres of cotton, even after being bleached, retain almost always some lime and oxyd of iron, which must be removed before we attempt to dye the cotton; because their presence would spoil the colour. This is done by steeping the cotton for some time in water acidulated with sulphuric acid.

Cotton, like silk, may be dyed without the assistance of heat. It is not nearly so easy to dye cotton any particular colour as it is to dye wool or silk. If wool and cotton be put into the same dyeing vessel, the wool frequently acquires the wished-for colour before the cotton has lost any of its original whiteness.

385 Linen.

4. LINT, from which *linen* is made, is the inner bark of the *linum usitatissimum*, or *flax*; a plant too well known in this country to require any description.

The flax, when ripe, is pulled and steeped for some days in water, in order to separate the green coloured glutinous matter which adheres to the inner bark. This matter undergoes a degree of putrefaction; carbonic acid gas and hydrogen gas, are disengaged*: it is decomposed, and carried off by the water. If the water, in which the flax is steeped, be completely stagnant, the putrefaction is apt to go too far, and to injure the fibres of the lint; but in a running stream, it does not go far enough, so that the green matter still continues to adhere to the lint. Flax, therefore, should be steeped in water neither completely stagnant, nor flowing too freely, like a running stream.

The flax is afterwards spread upon the grass, and exposed for some time to the air and sun: this improves the colour of the lint, and renders the woody part so brittle, that it is easily separated by the action of the lint mill. The subsequent operations, of *dressing*, *spinning*, *weaving*, and *bleaching*, do not belong to this article.

The fibres of lint have very little elasticity. They appear to be quite smooth; for no asperities can be perceived by the microscope, nor detected by the feel; nor does linen irritate sores, as is the case with cotton.

Linen may be dyed without the assistance of heat; but it is more difficult to give it permanent colours than even cotton.

Thus we have given a short description of wool, silk, cotton, and linen. The first two are animal substances; the two last vegetable. The animal contain much azot and hydrogen; the vegetable much carbon: The animal are readily destroyed by acids and alkalies; the vegetable withstand the action of these substances better; even nitric acid does not readily destroy the texture of cotton. The animal substances are more easily dyed than the vegetable, and the colours which they receive are more permanent than those given to cotton and linen by the same processes.

Such are the properties of the cloths on which the art of dyeing is exercised. But what is the nature of these *colours* which it is the object of that art to communicate? We shall examine this subject in the following chapter.

CHAP. II. OF COLOURS.

ALL visible objects, as has been long ago sufficiently established, are seen by means of rays of light passing off from them in all directions, and partly entering the eye of the spectator.

1. For the theory of light and vision we are indebted to Sir Isaac Newton. He first demonstrated, that light is composed of seven rays, differing from each other in refrangibility, and other properties. Each of these rays is distinguished by its particular colour. These are their names, red, orange, yellow, green, blue, indigo, violet. By mixing together these different rays, in various proportions, all the colours known may be obtained. Thus red and yellow constitute orange; yellow and blue constitute green; blue and red constitute purple, violate, aurora, &c. according to their proportions. When all the rays are mixed together, they form a white. 386 Colours produced by [...]

2. Bodies differ very much from each other in their power of reflecting light. Some reflect it in vast quantity, as metals; others reflect but little, as charcoal. In general, the smoother the surface of a body is, the greater is the quantity of light which it reflects. Hence the effect of polishing in increasing the brightness of bodies. But it is not in the quantity of the light reflected alone that bodies differ from each other, they differ also in the quality of the light which they reflect. Some bodies reflect one or more particular species of ray to the exclusion of the rest. This is the reason that they appear to us of different colours. Those bodies which reflect only red rays are red; those that reflect yellow rays are yellow; those that reflect all the rays equally are white; those that reflect too little to affect the eye are black. It is to the different combinations of rays reflected from the surface of bodies that all the different shades of colour are owing. Bodies reflect different rays.

Colour, then, in *opaque* bodies, is owing to their disposition to *reflect* certain rays of light, and to *absorb* the rest; in *transparent* bodies, to their disposition to *transmit* certain rays, and to *absorb* the others. But this subject has been discussed, at sufficient length, in the article OPTICS, *Encycl.*; to which, therefore, we beg leave to refer the reader. Here we mean only to inquire into the *cause* of this disposition of the particles of bodies. 388 Hence their different colours.

3. Sir Isaac Newton, to whom we are indebted for the existence of optics as a science, made a set of experiments to ascertain the changes of colour which thin plates of matter assume in consequence of an increase or dimi- 389 Newtonian theory to explain this difference

Colours

diminution of their thickneſs. Theſe experiments were of a very delicate nature; but Newton conducted them with ſo much addreſs, and varied and repeated them with ſo much induſtry, that he was enabled to render them ſurpriſingly accurate.

Upon a large double convex lens of a 50 feet focus, he placed the plane ſurface of a planoconvex lens, and preſſed the lenſes ſlowly together. A circle, of a particular colour, appeared in the centre, where the two glaſſes touched each other. This circle gradually increaſed in diameter as the preſſure was augmented; and at laſt a new circle, of another colour, occupied the centre, while the firſt colour aſſumed the form of a circular ring. By increaſing the preſſure, a new coloured circle appeared in the centre, and the diameter of the other two increaſed. In this manner he proceeded, till he produced no leſs than 25 different coloured circular rings. Theſe he divided into ſeven orders, on account of the repetition of the ſame colour. They were as follows, reckoning from the central colour, which was always black *.

* Newton's Optics, 19. Clarke's edition.

1. Black, blue, white, yellow, red.
2. Violet, blue, green, yellow, red.
3. Purple, blue, green, yellow, red
4. Green, red.
5. Greeniſh blue, red.
6. Greeniſh blue, pale red.
7. Greeniſh blue, reddiſh white.

Theſe different colours were occaſioned by the thin film of air between the two glaſſes. Now this film varies in thickneſs from the centre of the lens towards the circumference; that part of it which cauſes the black colour is thinneſt, and the other coloured circles are occaſioned by air gradually increaſing in thickneſs. Newton meaſured the *relative thickneſs* of the air which produced each of theſe coloured circles; and he found it as follows †:

† Ibid. p. 225.

1. Black		1	green	-	25 1/5
blue		2 1/5	yellow	-	27 1/7
white		5 1/5	red	-	31
yellow		7 1/6	4. Green	-	35
red		8 1/3	red	-	40 1/3
2. Violet	-	11 1/6	5. Gr. blue	-	46
blue	-	14	red	-	52 1/2
green		15 1/8	6. Gr. blue	-	58 3/4
yellow	-	16 1/7	red	-	65
red	-	18 1/3	7. Gr. blue	-	71
3. Purple	-	21	reddiſh white		77
blue	-	23 2/5			

The *abſolute* thickneſs of theſe films cannot be aſcertained, unleſs the diſtance between the two glaſſes, at that part where the black ſpot appears, were known. Now there is no method of meaſuring this diſtance; but it certainly is not greater than the thouſandth part of an inch.

He repeated theſe experiments with films of water, and even of glaſs, inſtead of air; and he found, that in theſe caſes the thickneſs of the films, reflecting any particular colour, was diminiſhed, and that this diminution was proportional to the denſity of the reflecting film.

Colours.

From theſe experiments Sir Iſaac Newton concluded, that the diſpoſition of the particles of bodies to reflect or tranſmit particular rays depended upon their ſize and their denſity: and he even attempted to aſcertain the ſize, or at leaſt the thickneſs, of the particles of bodies from their colours. Thus a particle of matter, whoſe denſity is the ſame with that of glaſs which reflects a green of the third order, is of the thickneſs of $\frac{16\frac{1}{4}}{1000000}$ of an inch *.

* Newton's Optics, 251.

In the year 1765, Mr Delaval publiſhed, in the Philoſophical Tranſactions, a very ingenious paper on the ſame ſubject. In this paper, he endeavours to prove, by experiment, that the colours of metallic bodies depend upon their denſity. He takes it for granted, at the ſame time, that the ſize of the particles of bodies is inverſely as the denſity of bodies. The denſeſt bodies, according to him, are red; the next in denſity, orange; the next, yellow; and ſo on, in the order of the refrangibility of the different rays. Some time after, the ſame ingenious gentleman, in his *Experimental Inquiry into the Cauſe of the Permanent Colours of Opaque Bodies*, extended his views to animal and vegetable ſubſtances, and endeavoured to prove the truth of Newton's theory by a very great number of experiments.

Such is a view of the opinion of Newton and Delaval reſpecting the cauſe of bodies reflecting or tranſmitting particular rays of light, as far, at leaſt, as that theory relates to colour. They aſcribed this cauſe *ſolely* to the *ſize* and the *denſity* of the particles of bodies.

By *particles*, it is evident that nothing elſe can be meant than the *integrant particles* of bodies. Newton, indeed, does not expreſs himſelf preciſely in this language; but it is plain that nothing elſe could be his meaning. Mr Delaval undoubtedly is of that opinion.

According to the Newtonian theory of colour, then, it depends ſolely upon the *ſize* of the integrant particles of bodies whoſe denſity is the ſame; and upon the *ſize* and the *denſity* jointly of all bodies (T).

390 Examined.

It is evident that the truth of the Newtonian theory muſt depend upon its coincidence with what actually takes place in nature, and that therefore it can only be determined by experiment. Newton himſelf produced but very few experiments in ſupport of it; and though this deficiency was amply ſupplied by Mr Delaval, it is needleſs for us to adduce any of theſe here; becauſe, from the prodigious accumulation of chemical facts ſince theſe experiments were made, the very baſis upon which they ſtood has been deſtroyed, and conſequently all the evidence reſulting from them has been annihilated. They proceeded on the ſuppoſition, that acids render the particles of bodies *ſmaller*, and alkalies *larger* than they were before, without producing any other change whatever in the bodies on which they act. To attempt a refutation of this opinion at preſent would be unneceſſary, as it is well known not to be true.

Let us therefore compare the Newtonian theory of colour with thoſe chemical changes which we know for certain to alter the ſize of the particles of bodies, in order to ſee whether they coincide with it. If the theory be true, the two following conſequences muſt hold

(T) Newton, however, pointed out an exception to this law, concerning which Mr Delaval has been more explicit. Combuſtible bodies do not follow that law, but ſome other. Mr Delaval has ſuppoſed, that this deviation is owing to the preſence of phlogiſton.

Colours. hold in all cases: 1. Every alteration in the size of the integrant particles of bodies must cause these particles to assume a different colour. 2. Every such alteration must correspond precisely with the theory; that is to say, the new colour must be the very colour, and no other, which the theory makes to result from an increase or diminution of size.

391 And found defective. Now neither of these consequences holds in fact. We have no method indeed of ascertaining the sizes of the integrant particles of bodies, nor of measuring the precise degree of augmentation or diminution which they suffer; but we can in many cases ascertain, whether any new matter has been added to a particle, or any matter abstracted from it; and consequently whether it has been augmented or diminished; which is sufficient for our present purpose.

For instance, whatever be the size of an integrant particle of gold, it cannot be denied that an integrant particle of oxyd of gold is greater; because it contains an integrant particle of gold combined with at least one integrant particle of oxygen. Now the colour both of gold and of its oxyd is yellow, which ought not to be the case, according to the Newtonian theory. In like manner, the amalgam of silver is white, precisely the colour of silver and of mercury; yet an integrant particle of the amalgam must be larger than an integrant particle either of silver or of mercury. Many other instances besides these will occur to every one, of changes in the size of the particles taking place without any change of colour. All these are incompatible with the Newtonian theory.

It may be said, perhaps, in answer to this objection, that there are different orders of colours; that the same colour is reflected by particles of different sizes; and that the increased particles, in the instances above alluded to, retain their former colour, because the increment has been precisely such as to enable them to reflect the same colour in the next higher order.

This very answer is a complete proof that the Newtonian theory is not sufficient to account for the colours of bodies; for if particles of *different* sizes reflect the same colour, *size* certainly is not the only cause of this reflection *. There must be some other cause very different from size. Nor is this all; the most common colour which remains after an increase of the size of the integrant particles of bodies is white; yet white does not appear in any of the orders except the first, and therefore its permanence cannot be accounted for by any supposition compatible with the Newtonian theory.

* *Bancroft on Permanent Colours*, i 7.

Even when alterations in the colour of bodies accompany the increase or diminution of the size of their particles, these alterations seldom or never follow an order which corresponds with the theory. As for metals, it is self-evident that their colour does not depend upon their density. Platinum is the densest body known, and yet it is not red, as it ought to be, but white like tin; a metal which has little more than one third of the density of platinum.

The green oxyd of iron, when combined with prussic acid, becomes white; yet the size of its particles must be increased. Now this change of colour is incompatible with the theory; for, according to it, every change from green to white ought to be accompanied by a diminution instead of an increase of size. A particle of indigo, which is naturally green, becomes blue by the addition of oxygen, which must increase its size. This change is also incompatible with the theory. But it is unnecessary to accumulate instances, as they will naturally occur in sufficient number to every one.

It follows irresistibly from these facts, that the Newtonian theory is not sufficient to explain the *cause* of colour; or what causes bodies to reflect or transmit certain rays, and to absorb the rest.

4. We have endeavoured, in the article CHEMISTRY, *Suppl.* to shew, that bodies have a particular affinity for the rays of light; and that the phenomena of light depend entirely upon these affinities. Indeed this consequence follows from the properties of light established by Newton himself. We shall not repeat here the proofs upon which the existence of these affinities is founded: the reader may easily satisfy himself by consulting the article above referred to. 392 Bodies owe their colour to their affinity for light.

Every coloured body, then, has a certain *affinity for* some of the rays of light. Those rays for which it has a strong affinity are absorbed by it and retained, and the other rays for which it has no affinity are either reflected or transmitted, according to the nature of the body and the direction of the incident ray. Thus a red body has an affinity for all the rays except the red; it absorbs therefore the other six, and reflects only the red: a green body absorbs all but the green rays, or perhaps the red and yellow: a black body has a strong affinity for all the rays, and therefore absorbs them all: while a white body, having no strong affinity for any of the rays, reflects or transmits them all.

If affinity, as we have endeavoured to shew in the article CHEMISTRY, *Suppl.* be an attraction of the same nature with gravitation, and increasing as the distance diminishes, it must depend upon the nature of the attracting particles. Now the only differences which we can conceive to exist between the particles of bodies, are differences in *size*, in *density*, and in *figure*. Changes in these three things will account for all the varieties of affinity. Now if affinity depends upon these three things, and if colour depends upon the affinity between the particles of bodies and the different rays of light as cannot be denied, it is clear that the cause of the colour of bodies may be ultimately resolved into the size, density, and figure, of their particles. Newton's theory, then, was defective, because he omitted the *figure* of the particles, and ascribed the whole to variations in *size* and *density*.

When we say, then, that colour is owing to *affinity*, we do not contradict the opinion of Newton, as some philosophers have supposed, but merely extend it. Newton was *not mistaken* in saying, that colour depends upon the size and the density of the particles of bodies; his mistake lay in supposing that it depends upon these *alone*.

5. Since the colour of bodies depends upon their affinity for light, and since every body has a certain colour, because it absorbs and retains particular rays while it transmits or reflects the rest, it is evident that every body must continue of its first colour till one of two things happen; either till it be saturated with the rays which it absorbs, and of course cease to absorb any more, or till its particles change their nature, by being either decomposed or combined with some new substance. We have no positive proof that the first cause 393 Why bodies change their colours.

Colours. cause of change ever occurs, as many substances have been exposed to the action of light for a very long time without any change of colour. The absorbed light seems to make its escape, either in its own form, or in some unknown or unsuspected one. The second cause of change is very common: indeed its action may be detected in almost every case of alteration in the colour of bodies. The green oxyd of iron, by combining with oxygen, becomes red; and this red oxyd, when combined with prussic acid, assumes a blue colour, and with gallic acid a black colour. The cause of this change of colour, when the composition of a body changes, is obvious: every change of composition must alter the affinity, because it must of necessity produce changes in the size, density, or figure of the particles, or perhaps in all of these. Now if the affinity of a body for other bodies be altered, it is natural to suppose that it will be altered also for light. Accordingly this happens in most instances. It does not, however, take place constantly, for very obvious reasons. It may happen that the new density, size, or figure of the altered body is such, as to render it still proper for attracting the very same rays of light which it formerly attracted. Just as iron, after being combined with a certain dose of oxygen, is converted into green oxyd, which still retains an affinity for oxygen.

It is evident from all this, that in most cases the permanence of colour in bodies will depend upon the permanence of their composition, or on the degree of facility with which they are acted upon by those bodies, to the agency of which they are exposed.

394 Permanency of colour of great importance in *dyeing*.

In *dyeing*, the permanence of colour is of very great importance. Of what value is the beauty of a colour, provided that colour be fugitive or liable to change into some other. In all cases, therefore, it is of consequence to attend to the substances to which dyed cloth is exposed, and to ascertain their action upon every particular dyeing ingredient. Now the bodies to which dyed cloth is almost constantly exposed are *air* and *light*; the combined action of which has so much influence, that very few dyes can resist it.

395 How dyes lose their colour.

It is evident that those substances which have a strong affinity for oxygen cannot retain their colour, provided they be able to take it from atmospheric air. Thus the green colour of green oxyd of iron and of indigo is not permanent, because these substances readily absorb oxygen from air. In order, then, that a colour can have any permanence, the coloured body must not have so great an affinity for oxygen as to be able to take it from air. Those bodies have in general the most permanent colours which are already saturated with oxygen, and therefore not liable to absorb more. Such is the case with red oxyd of iron.

All coloured bodies are compounds; some of those only excepted which still retain an affinity for oxygen. Coloured bodies, therefore, are composed of several ingredients; and in every coloured body, at least *some* of the ingredients have a strong affinity for oxygen. Now, before the colour of a body can be permanent, its ingredients must be combined together by so strong affinities, that oxygen gas is unable to decompose it by combining with one or more of its ingredients and carrying it off. If this decomposition take place at once, it is impossible for the colour of a body to have any permanence. If it takes place slowly, the colour of the body gradually decays. The action of oxygen gas upon bodies is much increased in particular circumstances. Almost all coloured bodies are decomposed by oxygen gas by the assistance of heat. Thus if wheat flour be exposed to the heat of 448°, it loses its white colour, and becomes first brown and then black. At this temperature it is decomposed, and a part, or even the whole of its hydrogen, combining with oxygen, flies off. Cloth is scarcely ever exposed to so high a temperature; but there are other circumstances in which it may be placed which may have a similar effect. Thus the action of light seems in some substances to be similar to that of heat, and to facilitate the decomposition of the coloured matter by the combination of some of its ingredients with oxygen *.

* Berthollet on Dyeing, i. 45.

Coloured bodies, in order to have permanent colours, must not be liable to be decomposed by other substances more than by oxygen. For instance, if they contain oxygen and hydrogen, these two bodies must not be liable to combine together and form water, nor must oxygen and carbon be liable to combine and form carbonic acid gas. Light seems to have a tendency to decompose many bodies in this manner, and even to carry off oxygen from them in the form of oxygen gas. Thus it renders the nitrat of silver black by carrying off part of its oxygen, and it reduces oxy-muriatic acid to common muriatic acid by the same means.

These are the causes which induce a change in the colour of coloured bodies, as far as they have been traced; namely, the addition of oxygen, the abstraction of oxygen, partial decomposition by some one of their ingredients combining with oxygen, complete or partial decomposition by the ingredients entering into new combinations with each other. The coloured matters used in dyeing are very liable to these changes, because they are in general, animal or vegetable substances of a very compound nature. Of course their ingredients have often no very strong affinity for each other, and therefore are very liable to decomposition; and every one of the ingredients has in general a very strong affinity for oxygen. This renders the choice of proper colouring matters for dyeing a very important point. In order to have permanency, they must not be liable to the above changes, not to mention their being able also to withstand the action of soap, acids, alkalies, and every other substance to which dyed cloth may be exposed.

396 Method of ascertaining the permanency of dyes.

It becomes therefore a point of some consequence to be able to ascertain whether cloth dyed of any particular colour be permanently dyed or not. The proper method of ascertaining this is by actually exposing such cloth to the sun and air; because as these are the agents to which it is to be exposed, and which have the most powerful action, it is clear, that if it withstand them, the colour must be considered as permanent. But this is a tedious process. Berthollet proposed exposing such cloth to the action of oxy-muriatic acid; those colours that withstand it being considered as permanent. This method answers in many cases: but it is not always to be depended on; for it destroys some permanent colours very speedily, and does not alter others which are very fading *. But we shall have occasion to resume this subject afterwards.

* Bancroft, i. 49.

397 Division of colours.

Dyers divide colours into two classes; namely, *simple* and *compound*. The simple colours are those which cannot

Dyeing in General. cannot be produced by the mixture of other colours. They are in number four.

1. Blue, 3. Red,
2. Yellow, 4. Black.

Some add a fifth, *brown*; but it may be produced by combining two others.

The compound colours are those which are produced by mixing together any two simple colours in various proportions. They constitute all the colours except the four simple and their various shades.

Thus we have examined the nature of colours; but we have still to explain the method of giving permanent colours to cloth. This shall be the subject of the next chapter.

Chap. III. Of Dyeing in General.

From the theory of colour laid down in the last chapter, it follows, that permanent alterations in the colour of cloth can only be induced two ways; either by producing a chemical change in the cloth, or by covering its fibres with some substance which possesses the wished-for colour. Recourse can seldom or never be had to the first method, because it is hardly possible to produce a chemical change in the fibres of cloth without spoiling its texture and rendering it useless. The dyer, therefore, when he wishes to give a new colour to cloth, has always recourse to the second method.

398 Dye-stuffs

1. The substances employed for this purpose are called *colouring matters*, or *dye stuffs*. They are for the most part extracted from *animal and vegetable substances*, and have usually the colour which they are intended to give to the cloth. Thus a blue colour is given to cloth by covering its fibres with indigo, a blue powder extracted from a shrub; a red colour, by the colouring matter extracted by water from an insect called *cochineal*, or from the root of a plant called *madder*.

399 Do not reflect light.

2. Mr Delaval has published a very interesting set of experiments on colouring matters in the second volume of the Manchester Memoirs. He has proved, by a very numerous set of experiments, that they are all transparent, and that they do not *reflect* any light, but only transmit it: For every colouring matter which he tried, even when dissolved in a liquid, and forming a transparent coloured solution, when seen merely by reflected light, was black, whatever was the colour of the matter; but when seen by transmitted light, it appeared of its natural colour *. This discovery, which Mr Delaval has established very completely, and to which, as far at least as dye stuffs are concerned, there are but few exceptions, is of very great importance to the art of dyeing, and explains several particulars which would otherwise be unintelligible.

* *Manch. Mem.* ii. 131.

Since the particles of the colouring matter with which cloth, when dyed, is covered, are transparent, it follows, that all the light reflected from dyed cloth must be reflected, not by the dye stuff itself, but by the fibres of the cloth below the dye stuff. The colour therefore does not depend upon the dye alone, but also upon the previous colour of the cloth. If the cloth be *black*, it that we cannot dye it any colour; because as no light in that case is reflected, none can be transmitted, whatever dye stuff we employ. If the cloth were red, or blue, or yellow, we could not dye it any colour except black; because as only red, or blue, or yellow rays were reflected, no other could be transmitted (x). Hence the importance of a fine white colour when cloth is to receive bright dyes: it then reflects all the rays in abundance; and therefore any colour may be given, by covering it with a dye stuff which transmits only some particular rays.

400 They must be combined with the cloth.

3. If the colouring matters were merely spread over the surface of the fibre of cloth by the dyer, the colours produced might be very bright, but they could not be permanent; because the colouring matter would be very soon rubbed off, and would totally disappear whenever the cloth was washed, or even barely exposed to the weather. The colouring matter, then, however perfect a colour it possesses, is of no value, unless it also adheres so firmly to the cloth, that none of the substances usually applied to cloth in order to clean it, &c. can displace it. Now this can only happen when there is a strong *affinity* between the colouring matter and the cloth, and when they are actually combined together in consequence of that affinity.

401 Can only be applied in a state of solution.

4. Dyeing, then, is merely a chemical process, and consists in combining a certain colouring matter with the fibres of cloth. This process can in no instance be performed, unless the dye stuff be first reduced to its integrant particles; for the attraction of aggregation between the particles of dye stuffs is too great to be overcome by the affinity between them and cloth, unless they could be brought within much smaller distances than is possible, while they both remain in a solid form. It is necessary, therefore, previously to dissolve the colouring matter in some liquid or other, which has a weaker affinity for it than the cloth has. When the cloth is dipped into this solution, the colouring matter, reduced by this contrivance to a liquid state, is brought within the attracting distance; the cloth therefore acts upon it, and by its stronger affinity takes it from the solvent, and fixes it upon itself. By this contrivance, too, the equality of the colour is in some measure secured, as every part of the cloth has an opportunity of attracting to itself the proper proportion of colouring particles.

The facility with which cloth imbibes a dye, depends upon two things, namely, the affinity between the cloth and the dye stuff, and the affinity between the dye stuff and its solvent. It is directly as the former, and inversely as the latter. It is of importance to preserve a due proportion between these two affinities, as upon that proportion much of the accuracy of dyeing depends. If the affinity between the colouring matter and the cloth be too great, compared with the affinity between the colouring matter and the solvent, the cloth will take the dye too rapidly, and it will be scarce possible to prevent its colour from being unequal. On the other hand, if the affinity between the colouring matter and the solvent be too great, compared with that

(x) These remarks hold only on the supposition, that the *whole* of the surface is of the given colour, which in many instances is not the case.

that between the colouring matter and the cloth, the cloth will either not take the colour at all, or it will take it very flowly and very faintly.

Wool has the ftrongeft affinity for almoft all colouring matters, filk the next ftrongeft, cotton a confiderably weaker affinity, and linen the weakeft affinity of all. Therefore, in order to dye cotton or linen, the dye ftuff fho in many cafes be diffolved in a fubftance for which it has a weaker affinity than for the folvent employed in the dyeing of wool or filk. Thus we may ufe oxyd of iron diffolved in fulphuric acid, in order to dye wool; but for cotton and linen, it is better to diffolve it in acetous acid.

402 Nature of mordants.

5. Were it poffible to procure a fufficient number of colouring matters having a ftrong affinity for cloth, to anfwer all the purpofes of dyeing, that art would be exceedingly fimple and eafy. But this is by no means the cafe: if we except indigo, the dyer is fcarcely poffeffed of a dye ftuff which yields of itfelf a good colour fufficiently permanent to deferve the name of a dye.

This difficulty, which at firft fight appears infurmountable, has been obviated by a very ingenious contrivance. Some fubftance is pitched upon which has a ftrong affinity both for the cloth and the colouring matter. This fubftance is previoufly combined with the cloth, which is then dipped into the folution containing the dye ftuff. The dye ftuff combines with the intermediate fubftance; which, being firmly combined with the cloth, fecures the permanence of the dye. Subftances employed for this purpofe are denominated *mordants* (Y).

The moft important part of dyeing is undoubtedly the proper choice and the proper application of mordants, as upon them the permanency of almoft every dye depends. Every thing which has been faid refpecting the application of colouring matters, applies equally to the application of mordants. They muft be previoufly diffolved in fome liquid, which has a weaker affinity for them than the cloth has to which they are to be applied; and the cloth muft be dipped, or even fteeped, in this folution, in order to faturate itfelf with the mordant.

Almoft the only fubftances ufed as mordants are, earths, metallic oxyds, tan, and oil

403 Earthy mordants.

6. Of earthy mordants, by far the moft important and moft generally ufed is alumina. It was ufed as a mordant in very early ages, and feems indeed to have been the very firft fubftance employed for that purpofe. Alumina has a very ftrong affinity for wool and for filk; but its affinity for cotton and linen is a good deal weaker.

It is ufed as a mordant in two ftates; either in the ftate of alum, in which it is combined with fulphuric acid and a little potafs; or in the ftate of acetite of alumina, in which it is combined with acetous acid.

Alum was employed as a mordant very early. The ancients, indeed, do not feem to have been generally acquainted with pure alum, they ufed it in that ftate of impurity in which it is found native; of courfe it was ufed in dyeing long before the nature of its ingredients was underftood, and therefore long before the part which it acts was fufpected. Indeed, it is but a very fhort time fince the office which mordants perform was fufpected: the firft perfon that hit upon it was Mr Keir; he gave an account of the real ufe of mordants in his tranflation of Macquer's Dictionary, publifhed in 1771 *.

* Macquer, p. 215.

Alum, when ufed as a mordant, is diffolved in water, and very frequently a quantity of tartar is diffolved along with it. Into this folution the cloth is put and kept in it till it has abforbed as much alumina as is neceffary. It is then taken out, and for the moft part wafhed and dried. It is now a good deal heavier than it was before, owing to the alumina which has combined with it. The tartar ferves two purpofes: the potafs which it contains combines with the fulphuric acid of the alum, and thus prevents that very corrofive fubftance from injuring the texture of the cloth, which otherwife might happen; the tartarous acid, on the other hand, combines with part of the alumina, and forms a tartrite of alumina, which is more eafily decompofed by the cloth than alum.

Acetite of alumina has been introduced into dyeing fince the commencement of the 18th century; and, like many other very important improvements, we are indebted for it to the ignorance of the calico printers, who firft introduced it. As they did not underftand the nature nor ufe of the mordants which they employed, they were accuftomed to mix with their alum an immenfe farrago of fubftances, a great proportion of which were injurious inftead of being of fervice. Some one or other had mixed with alum acetite of lead: the good effects of this mixture would be foon perceived; the quantity of acetite was gradually increafed, and the other ingredients omitted *. This mordant is now prepared, by pouring acetite of lead into a folution of alum: a double decompofition takes place, the fulphuric acid combines with the lead, and the compound precipitates in the form of an infoluble powder; while the alumina combines with the acetous acid, and remains diffolved in the liquid. This mordant is employed for cotton and linen, which have a weaker affinity than wool for alumina. It anfwers much better than alum, the cloth is more eafily faturated with alumina, and takes, in confequence, both a richer and a more permanent colour.

* Bancroft, p. 176.

Befides alumina, *lime* is fometimes ufed as a mordant. Cloth has a ftrong enough affinity for it; but in general it does not anfwer fo well, as it does not give fo good a colour. When ufed, it is either in the ftate of lime-water or of fulphat of lime diffolved in water.

404 Metallic mordants.

7. Almoft all the metallic oxyds have an affinity for cloth; but only two of them are extenfively ufed as mordants, namely, the oxyds of tin and of iron.

The oxyd of tin was firft introduced into dyeing by Kufter (Z), a German chemift, who brought the fecret to London in 1543. This period forms an era in the hiftory of dyeing. The oxyd of tin has enabled the moderns

(Y) This term, impofed by the French dyers before the action of mordants was underftood, fignifies *biters* or *corroders*. Thefe bodies were fuppofed to act merely by corroding the *cloth*. Mr Henry of Manchefter has propofed to fubftitute the word *bafis* for *mordant*; but that word is too general to anfwer the purpofe well.

(Z) Mr Delaval has fuppofed, that the Tyrians were acquainted with the ufe of tin in dyeing, and Mr Henry

Dyeing in General.

moderns greatly to surpass the ancients in the fineness of their colours: by means of it alone, *scarlet*, the brightest of all colours, is produced. The method of producing the celebrated purple dye of the ancients is understood at present, and the shell fish which yield the dye stuff are found abundantly on the coasts of Britain and France; but no person thinks now of putting the ancient mode in practice, because infinitely more beautiful colours can be produced at a smaller price. Much of this superiority is owing to the employment of the oxyd of tin.

Tin, as Proust has proved, is capable of two degrees of oxydation: The first oxyd is composed of 0.70 parts of tin, and 0.30 of oxygen; the second, or white oxyd of 0.60 parts of tin, and 0.40 of oxygen *. The first oxyd absorbs oxygen with very great facility even from the air, and is rapidly converted into white oxyd. This fact makes it certain, that it is the white oxyd of tin alone which is the real mordant: even if the other oxyd were applied to cloth, as it probably often is, it must soon be converted into white oxyd, by absorbing oxygen from the atmosphere.

* Ann. de Chim. xxviii 213.

Tin is used as a mordant in three states; dissolved in nitro-muriatic acid, in acetous acid, and in a mixture of sulphuric and muriatic acids. Nitro-muriat of tin is the common mordant employed by dyers. They prepare it by dissolving tin in diluted nitric acid, to which a certain proportion of muriat of soda, or of ammonia, is added. Part of the nitric acid decomposes these salts, combines with their base, and sets the muriatic acid at liberty. They prepared it at first with nitric acid alone; but that mode was very defective; because the nitric acid very readily converts tin to white oxyd, and then is incapable of dissolving it. The consequence of which was, the precipitation of the whole of the tin. To remedy this defect, common salt, or sal ammoniac, was very soon added; muriatic acid having the property of dissolving white oxyd of tin very readily. A considerable saving of nitric acid might be obtained, by employing as much sulphuric acid as is just sufficient to saturate the base of the common salt, or sal ammoniac, employed.

When the nitro-muriat of tin is to be used as a mordant, it is dissolved in a large quantity of water, and the cloth is dipped in the solution, and allowed to remain till sufficiently saturated. It is then taken out, and washed and dried. Tartar is usually dissolved in the water along with the nitro-muriat. The consequence of this is a double decomposition; the nitro-muriatic acid combines with the potass of the tartar, while the tartarous acid dissolves the oxyd of tin. When tartar is used, therefore, in any considerable quantity, the mordant is not a nitro-muriat, but a tartrite of tin.

Mr Haussman, to whom the art of dyeing lies under numerous obligations, has proposed to substitute acetite of tin for nitro-muriat as a mordant for cotton and linen. It may be prepared by mixing together acetite of lead and nitro-muriat of tin. This mordant is preferable for these stuffs; because it is much more easily decomposed than the nitro muriat †.

† Ann de Chim. xxx.

Dr Bancroft has proposed to substitute a solution of tin in a mixture of sulphuric and muriatic acid, instead of nitro-muriat of tin, as a mordant for wool. This mordant, he informs us, is much cheaper, and equally efficacious. It may be prepared by dissolving somewhat less than one part of tin in two parts of sulphuric and three of muriatic acid, at the degree of concentration at which they are commonly sold in this country ‡. This mordant, like the others, must be dissolved in a sufficient quantity of water, in order to be used

‡ Bancroft, 293.

Iron, like tin, is capable of two degrees of oxydation; but the green oxyd absorbs oxygen so readily from the atmosphere, that it is very soon converted into the red oxyd. It is only this last oxyd which is really used as a mordant in dyeing. The green oxyd is indeed sometimes applied to cloth; but it very soon absorbs oxygen, and is converted into the red oxyd. This oxyd has a very strong affinity for all kinds of cloth. The permanency of the iron spots on linen and cotton is a sufficient proof of this. As a mordant, it is used in two states; in that of sulphat of iron, and acetite of iron. The first is commonly used for wool. The salt is dissolved in water, and the cloth dipped in it. It may be used also for cotton; but in most cases acetite of iron is preferred. It is prepared by dissolving iron, or its oxyd, in vinegar, sour beer, &c. and the longer it is kept, the more is it preferred. The reason is, that this mordant succeeds best when the iron is in the state of red oxyd. It would be better then to oxydate the iron, or convert it into rust, before using it; which might easily be done, by keeping it for some time in a moist place, and sprinkling it occasionally with water. Of late, pyrolignous acid has been introduced instead of acetous. It is obtained by distilling wood or tar.

405 Tan.

8. Tan, which has been already described in the first part of this article, has a very strong affinity for cloth, and for several colouring matters. It is therefore very frequently employed as a mordant. An infusion of *nut galls*, or of *sumach* (A), or any other substance containing tan, is made in water, and the cloth is dipped in this infusion, and allowed to remain till it has absorbed a sufficient quantity of tan. Silk is capable of absorbing a very great proportion of tan, and by that means acquires a very great increase of weight. Manufacturers sometimes employ this method of increasing the weight of silk §.

§ Berthollet, ii. 10.

Tan is often employed also, along with other mordants, in order to produce a compound mordant. Oil is also used for the same purpose in the dyeing of cotton and linen. The mordants, with which tan most frequently is combined, are alumina and oxyd of iron.

406 Other mordants.

Besides these mordants, there are several other substances frequently used as auxiliaries, either to facilitate the combination of the mordant with the cloth, or to alter

ry has declared himself of the same opinion. But his reasoning, as Dr Bancroft has shewn, proceeds upon a mistake. He supposes that tin is *necessary* for the production of red colours.

(A) Sumach is the *rhus coriaria*; a shrub which is cultivated in the southern parts of Europe. Its shoots are dried, and afterwards ground to powder; in which state they are sold to the dyer and tanner.

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alter the shade of colour. The chief of these are, *tartar, acetite of lead, common salt, sal ammoniac, sulphat* or *acetite of copper*, &c.

407 Mordants affect the colour.

9. Mordants not [illegible] render the dye permanent, but have also conside[illegible] influence on the colour produced. The same co[illegible] matter produces very different dyes, according as the mordant is changed. Suppose, for instance, that the colouring matter be cochineal; if we use the aluminous mordant, the cloth will acquire a crimson co[illegible]our; but the oxyd of iron produces with it a black. These changes, indeed, might naturally have been expected: for since the colour of a dye stuff depends upon its affinity for light, every new combination into which it enters, having a tendency to alter these affinities, will naturally give it a new colour. Now, in all cases, the colouring matter and mordant combine together: the colour of the cloth, then, must be that which the particles of the dye and of the mordant, when thus combined together, exhibit. Indeed some mordants may be considered in the light of colouring matters also, as they always communicate a particular colour to cloth. Thus, iron communicates a brown colour, and iron and tan together constitute a black dye.

In dyeing, then, it is not only necessary to procure a mordant, which has a sufficiently strong affinity for the colouring matter and the cloth, and a colouring matter which possesses the wished-for colour in perfection, we must procure a mordant and a colouring matter of such a nature, that when *combined together* they shall possess the wished-for colour in perfection. It is evident, too, that a great variety of colours may be produced with a single dye stuff, provided we can change the mordant sufficiently.

408 How applied.

10. Every thing which tends to weaken the affinity between the mordant and the cloth, or between the mordant and the colouring matter, and every thing which tends in any way to alter the nature of the mordant, must injure the permanency of the dye: because, whenever the mordant is destroyed, there is no longer any thing to cause the dye stuff to adhere; and when its nature is altered, the colour of the dye must alter at the same time. All the observations, then, which were made in the last chapter, concerning the nature of colouring matters, and the changes to which they are subject, apply equally to mordants. These substances, indeed, are scarcely liable themselves to any alteration. They are of a much more simple nature, in general, than dye stuffs; and therefore not nearly so liable to decomposition. But when the colouring matter itself is altered, it comes to the same thing. Its affinity for the mordant being now destroyed, there is nothing to retain it.

As the permanency of a dye depends upon the degree of affinity between the mordant and the colouring matter, it is clear that a dye may want permanency, even though it resist the oxy muriatic acid, and all the other saline tests proposed by chemists. These substances may happen to have very little action on the dye stuff, and therefore may not affect it; yet it may soon disappear, in consequence of its want of affinity for the mordant.

11. The colouring matter with which cloth is dyed, does not cover every portion of its surface; its particles attach themselves to the cloth at certain distances from each other: for cloth may be dyed different shades of the same colour, lighter or darker, merely by varying the quantity of colouring matter. With a small quantity, the shade is light; and it becomes deeper as the quantity increases. Now this would be impossible, if the dye stuff covered the whole of the cloth. Newton has demonstrated, that colours are rendered faint when the rays of light which occasion them are mixed with white rays. Consequently, from cloth dyed of a light shade, a considerable quantity of white rays passes off unchanged: but this could not be the case if the stuff were covered with coloured matter; because all the white rays would be decomposed as they pass through the coloured matter. Therefore, in light shades, the colouring matter does not cover the cloth; its particles adhere to it, at a certain distance from each other, and from every part of the cloth which is uncovered, the white rays pass off unchanged. Even when the shade of colour is as deep as possible, the colouring particles do not cover the whole of the cloth, but are at a certain distance from each other. This distance, undoubtedly, is diminished in proportion to the deepness of the shade: for the deeper the shade, the smaller is the number of white rays which escape undecompos[e]d; the more, therefore, of the surface is covered, and, consequently, the smaller is the distance at which each of them is placed. A shade may be even conceived so very deep, that not a particle of white light escapes the action of the colouring matter; in which case, the distance between the particles of colouring matter could not exceed double that distance at which a particle of matter is able to act upon light.

409 Dye-stuffs do not cover the whole surface of the cloth.

410 Compound colours.

That the particles of colouring matter, even when the shade is deep, are at some distance, is evident from this well-known fact, that cloth may be dyed two colours at the same time. All those colours, to which the dyers give the name of *compound*, are in fact two different colours applied to the cloth at once. Thus cloth gets a *green* colour, by being first dyed *blue* and then *yellow*. The rays of light that pass from green cloth thus dyed are blue and yellow; by the mixture of which it is well known that green is produced. In this case, it is clear, that each of the colouring matters performs the very same office as if it were alone; and that the new colour is not produced by the combination of the two colouring matters. That part of the white light, reflected from the cloth, which passes through the blue colouring matter, is decomposed, and the blue rays only transmitted; and that part of the white light which passes through the yellow colouring matter is also decomposed, and only the yellow rays transmitted. It is clear, therefore, that both of the colouring matters equally cover the naked fibres of the cloth; consequently the one must be placed in the intervals of the other: wherefore the particles of each of the colouring matters are at some distance. Now the same effect happens how deep soever the shade be; and it makes no difference which of the two dyes be first given. Nay, if one of the dyes have a strong affinity for the cloth, and the other only a weak affinity, the latter will soon disappear, and leave the cloth of the [illegible]our which the first dye gives it.

The difference, then, in the shade of colour, and also the compound colours which cloth may receive, depend entirely upon the distance between the particles of the colouring matters attached to the cloth, and the possibility

Blue. lity of partly filling up the intervals, either with the same colouring matter, or with a different one.

Thus we have taken a view of the theory of dyeing, as far, at least, as it is at present understood. It remains for us still to give an account of the particular manner by which each of the colours is imparted to cloth. This shall be the subject of the three following chapters. In the *first* we shall treat of the manner of dyeing the simple colours; in the *second*, of dyeing the compound colours; and in the *third*, of dyeing cloth partially several different colours at the same time, or of that branch of the art of dyeing which is known in this country by the name of *calico printing*.

CHAP. IV. OF DYEING SIMPLE COLOURS.

THE colours denominated by dyers *simple*, because they are the foundation of all their other processes, are four; namely, *1st*, blue;—*2d*, yellow;—*3d*, red:—*4th*, black. To these they usually add a fifth, under the name of *root*, or brown colour. These shall form the subject of the following sections.

SECT. I. *Of BLUE*.

THE only colouring matters employed in dyeing blue are *woad* and *indigo*: attempts, indeed, have been made to dye with prussiat of iron; but these attempts have hitherto failed.

1. The *isatis tinctoria*, or *woad*, is a plant commonly enough cultivated in this kingdom, and even found wild in some parts of England. It is of a yellowish colour. Some persons think that it was this plant with which the ancient Britons stained their bodies, to make them appear terrible to their enemies. When arrived at maturity, this plant is cut down, washed, dried hastily in the sun, ground in a mill, placed in heaps, and allowed to ferment for a fortnight; then well mixed together, formed into balls, which are piled upon each other, and exposed to the wind and sun. In this state they gradually become hot, and exhale a putrid ammoniacal smell. The fermentation is promoted, if necessary, by sprinkling the balls with water. When it has continued for a sufficient time, the woad is allowed to fall to a coarse powder. In this state it is sold to the dyers.

2. Indigo, is a blue coloured powder extracted from the *indigofera tinctoria*, and from several other species of the same genus of plants, which are cultivated for that purpose both in the East and West Indies.

When the *indigofera* has arrived at maturity, it is cut a few inches above ground, placed in strata in a large vessel, and covered with water. The plants soon acquire heat, ferment, and discharge abundance of carbonic acid gas. When the fermentation is far enough advanced, which is judged of by the paleness of the leaves, the liquid, now of a green colour, is decanted into large flat vessels, where it is constantly agitated till blue flocculæ begin to make their appearance. Lime water is now poured in, which causes the blue flocks to precipitate. The colourless liquid is decanted off, and the blue sediment poured into linen bags. When the water has drained from it sufficiently, it is formed into small lumps, and dried in the shade. In this state it is sold to the dyer under the name of *indigo*.

Dr Roxbourgh, who first drew the attention of manufacturers to the *nerium tinctorium*, a tree very common in Indostan, from the leaves of which indigo may be extracted with much advantage, has given a much shorter method of obtaining that pigment. The leaves are kept in a copper full of water, supported at the temperature of 160°, till they assume a yellowish hue, and the liquid acquire a deep green colour. The liquid is then to be drawn off, agitated in the usual manner, till the blue flocculæ appear; and then the indigo is be precipitated with lime water *.

This process, which succeeds equally well with the indigofera, shews us that the plants, from which indigo may be extracted, contain a peculiar green pollen, soluble in water. The intention, both of the fermentation of the common method, and of the scalding, according to Dr Roxbourgh's method, is merely to extract this pollen. Mr Haussman first shewed, that this green basis of indigo has a strong affinity for oxygen; and the subsequent experiments of Drs Roxbourgh and Bancroft have confirmed his observations, and put them beyond the reach of doubt. It gradually attracts oxygen from the air; in consequence of which, it acquires a blue colour, and becomes insoluble in water. The agitation is intended to facilitate this absorption, by exposing a greater surface to the action of the air. The lime water, by absorbing a quantity of carbonic acid, with which the green pollen seems to be combined, greatly facilitates the separation of the indigo.

The method of preparing indigo, and of applying it to the purposes of dyeing, seems to have been very early known in India. But in Europe, though it had been occasionally used as a paint *, its importance as a dye stuff was not understood before the middle of the 16th century. It is not even mentioned in the *Plictho*, which was published in 1548. At that period, then, the use of indigo must have been unknown to the Italian dyers. The Dutch were the people who first imported it from India, and made its importance known in Europe. It was afterwards cultivated in Mexico and the West Indies with such success, that the indigo from these countries was preferred to every other. In consequence of this preference, they supplied almost the whole of the European market. But within these few years, the East Indian indigo, owing entirely to the enlightened exertions of some of our own countrymen, has recovered its character, and is now imported, in very considerable quantities, into Britain.

The indigo of commerce has different shades of colour, according to the manner in which it has been prepared, and the proportion of foreign substances with which it is mixed. The principal shades are copper colour, violet, and blue. That indigo, which has the smallest specific gravity, is always most esteemed; because it is most free from impurities. Bergman † found the purest indigo of commerce which he could procure, composed of

47 pure indigo,
12 gum,
6 resin,
22 earth,
13 oxyd of iron.
100 (B).

* Ban. 41?
* [illegible] 35
† [illegible] 36

(B) Proust informs us, that he found magnesia, even abundantly, in indigo.—*Nicholson's Jour.* III. 325.

Blue.

415 Its properties.

Pure indigo is insoluble in water, alcohol, ether, and oils: neither alkalies nor earths have any action on it; none of the acids hitherto tried have any effect on it, except the nitric and sulphuric. Nitric acid very soon converts it into a dirty white colour, and at last decomposes it completely*. When the acid is concentrated, it even sets fire to the indigo (c); when it is diluted, the indigo becomes brown, crystals make their appearance, resembling those of oxalic and tartarous acid, and there remains behind, after the acid and the crystals are washed off, a viscid substance, of a very bitter taste, and possessing many of the properties of a resin †.

* Berg. v.

† Hat.

Concentrated sulphuric acid dissolves indigo readily, and much heat is evolved. The saturated solution is opaque, and consequently black; but it assumes a deep blue colour when diluted with water. This solution is well known in commerce under the name of *liquid blue*. Bancroft has given it the name of *sulphat of indigo*. During the solution of the indigo, some sulphurous acid, and some hydrogen gas, are evolved ‡, and the blue colour of the indigo is much heightened. These facts have led Bancroft to suppose, that the indigo, during its solution combines with an additional quantity of oxygen *. This *may* possibly be the case, but the phenomena are not sufficient to establish it: for the hydrogen gas and sulphurous acid evolved may owe their formation not to the action of the sulphuric acid on indigo, but upon the impurities with which it is always mixed; and the improvement of the colour may be owing to the absence of these impurities. The carbonats of fixed alkalie precipitate slowly from sulphat of indigo a blue coloured powder, which possesses the properties of indigo; but it is soluble in most acids and in alkalies. Pure alkalies destroy the colour and properties of sulphat of indigo: they destroy also precipitated indigo §. These facts give some probability to Bancroft's opinion; but they do not establish it: because the differences between common and precipitated indigo may depend merely on the state of greater minuteness to which it is reduced, which prevents the attraction of aggregation from obstructing the action of other bodies. Even silica, when newly precipitated, is soluble in many menstrua.

‡ Id.

* Bancr. i. 150.

§ Berg. v.

416 Method of dyeing with sulphat of indigo.

3. Indigo has a very strong affinity for wool, silk, cotton, and linen. Every kind of cloth, therefore, may be dyed with it, without the assistance of any mordant whatever. The colour thus induced is very permanent; because the indigo is already saturated with oxygen, and because it is not liable to be decomposed by those substances, to the action of which the cloth is exposed. But it can only be applied to cloth in a state of solution; and the only solvent known being sulphuric acid, it would seem at first sight that the sulphuric acid solution is the only state in which indigo can be employed as a dye.

The sulphat of indigo is indeed often used to dye wool and silk blue; but it can scarcely be applied to cotton and linen, because the affinity of these substances for indigo is not great enough to enable them readily to decompose the sulphat. The colour given by sulphat of indigo is exceedingly beautiful: it is known by the name of Saxon blue; because the process, which was discovered by councellor Barth in 1740, was first carried on at Grossenhayn in Saxony. The method of the original inventor was very complicated, from the great number of useless ingredients which were mixed with the sulphat. But these ingredients were gradually laid aside, and the composition simplified by others, after the nature of it, which was for some time kept secret, became known to the public. The best process is that of Mr Poerner *.

* Instruction sur l'Art de la Teinture, p. 183.

One part of indigo is to be dissolved in four parts of concentrated sulphuric acid; to the solution one part of dry carbonat of potass is to be added, and then it is to be diluted with eight times its weight of water. The cloth must be boiled for an hour in a solution, containing five parts of alum and three of tartar for every 32 parts of cloth. It is then to be thrown into a water bath, containing a greater or smaller proportion of the diluted sulphat of indigo, according to the shade which the cloth is intended to receive. In this bath it must be boiled till it has acquired the wished-for colour. The alum and tartar are not intended to act as mordants, but to facilitate the decomposition of the sulphat of indigo. Bergman ascertained that alum possesses this property. The alkali added to the sulphat answers the same purpose. These substances, also, by saturating part of the sulphuric acid, serve, in some measure, to prevent the texture of the cloth from being injured by the action of the acid, which is very apt to happen in this process.

417 Method of dyeing by decomposing indigo.

4. But sulphat of indigo is by no means the only solution of that pigment employed in dyeing. By far the most common method, and indeed the only method known before 1740, is to deprive indigo of the oxygen to which it owes its blue colour, and thus to reduce it to the state of green pollen; and then to dissolve it in water by means of alkalies, or alkaline earths, which in that state act upon it very readily. Indigo is precisely in the state of green pollen when it is first extracted from the plant in the scalding process described by Dr Roxbourgh. If, therefore, there were any method of stopping short here, and of separating the pigment while it retains its green colour, it would be precisely in the state best adapted for dyeing. Nothing more would be necessary but to dissolve it in water by means of an alkali, and to dip the cloth into the solution †.

† Bancroft.

But as indigo is not brought home to us in that state, the dyer is under the necessity of undoing the last part of the indigo maker's process, by separating again the oxygen, and restoring it to its original green colour. Two different methods are employed for this purpose. The first of these methods is to mix with indigo a solution of some substance which has a stronger affinity for oxygen than the green basis of indigo. Green oxyd of iron for instance, and different metallic sulphurets. If, therefore, indigo, lime, and green sulphat of iron, be mixed together in water, the indigo gradually

(c) The combustion of indigo by nitric acid, of the density 1.52°, was first published by Mr Sage; but Woulfe appears to have observed the fact before him, and to have pointed it out to Rouelle, who shewed it in his lectures. *Proust, Nicholson's Jour.* III. 325.

gradually loses its blue colour, becomes green, and is dissolved, while the green oxyd of iron is converted into the red oxyd. The manner in which these changes take place is obvious. Part of the lime decomposes the sulphat of iron; the green oxyd, the instant that it is set at liberty, attracts oxygen from the indigo, decomposes it, and reduces it to the state of green pollen. This green pollen is immediately dissolved by the action of the rest of the lime. In like manner, indigo is dissolved, when mixed in water, with pure antimony and potass, or with sulphuret of arsenic and potass. For these interesting facts we are indebted to Mr Hauffman.

The second method is to mix the indigo in water with certain vegetable substances which readily undergo fermentation. During this fermentation, the indigo is deprived of its oxygen, and dissolved by means of quicklime or alkali, which is added to the solution. The first of these methods is usually followed in dyeing cotton and linen; the second, in dyeing wool and silk.

418 How to induce a blue colour on wool,

5. In the dyeing of wool, woad and bran are commonly employed as vegetable ferments, and lime as the solvent of the green base of the indigo. Woad contains itself a colouring matter precisely similar to indigo; by following the common process, indigo may be extracted from it. In the usual state of woad, when purchased by the dyer, the indigo which it contains is probably not far from the state of green pollen. Its quantity in woad is but small, and it is mixed with a great proportion of other vegetable matter. Before the introduction of indigo into Europe, woad alone was employed as a blue dye; and even as late as the 17th century, the use of indigo was restricted in different countries, and dyers obliged to employ a certain quantity of woad (D). But these absurd restrictions were at last removed, and woad is now scarcely used in dyeing, except as a ferment to indigo. The blue colouring matter, however, which it contains, must, in all cases, contribute considerably to the dye.

A sufficient quantity of woad, mixed with bran, is put into a wooden vessel filled with warm water, whose temperature is kept up sufficiently to ensure fermentation. Afterwards quicklime and indigo are added. The indigo is deprived of its oxygen, and dissolved by the lime. When the solution is complete, the liquid has a green colour, except at the surface, where it is copper coloured, or blue, because the indigo at the surface absorbs oxygen from the air, and assumes its natural colour. The woollen cloth is dipped in, and passed thro' the liquid as equably as possible, piece after piece; those pieces being first dyed which are to assume the deepest shade. No part of the cloth should come in contact with the sediment, which would spoil the colour. When the cloth is first taken out of the vat, it is of a green colour; but it soon becomes blue, by attracting oxygen from the air. It ought to be carefully washed, to carry off the uncombined particles. This solution of indigo is liable to two inconveniences: 1. It is apt sometimes to run too fast into the putrid fermentation: this may be known by the putrid vapours which it exhales, and by the disappearing of the green colour. In this state it would soon destroy the indigo altogether. The inconvenience is remedied by adding more lime, which has the property of moderating the putrescent tendency. 2. Sometimes the fermentation goes on too languidly. This defect is remedied by adding more bran or woad, in order to diminish the proportion of quicklime. Yellow.

419 Silk,

6. Silk is usually dyed blue by the following process: Six parts of bran, and six of indigo, with nearly one part of madder, are stirred into a sufficient quantity of water, in which six parts of common potash of commerce is dissolved. The liquid is kept at a temperature proper for fermentation. When the indigo, deprived of its oxygen by the fermentation, is dissolved by the potash, the liquid assumes a green colour. The silk, previously well scoured, is put into the solution in small quantities at a time; then wrung out of the dye, and hung up in the open air, till the green colour which it has at first is changed into blue. By this method, silk can only be made to receive a light blue colour. In order to give silk a dark blue, it must previously receive what is called a ground colour: that is, be previously dyed some other colour. A particular kind of red dye-stuff, called *archil* (E), is commonly employed for this purpose.

The madder employed in the above process may, at first sight, appear superfluous: it seems, however, to contribute something to the colour.

Cotton and linen.

7. Cotton and linen are dyed blue by the following process: One part of indigo, one part of green sulphat of iron, and two parts of quicklime, are stirred into a sufficient quantity of water. The solution is at first green, but it gradually assumes a yellow colour, and its surface is covered with a shining copper coloured pellicle. The cloth is to be allowed to remain in the solution for five or six minutes. When taken out, it has a yellow colour; but on exposure to the atmosphere, it soon becomes green, and then blue, in consequence of the absorption of oxygen. The indigo, in this process, seems to be deprived of a greater quantity of oxygen than is necessary to reduce it to the state of green pollen. Mr Hauffman has observed, that the cloth acquires a much deeper colour, provided it be plunged, the instant it is taken out of the dyeing vat, into water acidulated with sulphuric acid. It is usual to dip the cloth into a succession of vats, variously charged with colouring matter; beginning with the vat which contains least colouring matter, and passing gradually to those which contain most. By this contrivance the cloth is dyed more equally, than it probably would be, if it were plunged all at once into a saturated solution of colouring matter.

SECT. II. *Of Yellow*.

421 Yellow dyes.

THE principal colouring matters employed to dye yellow are *weld*, *fustic*, and *quercitron bark*.

1. Reseda luteola, known in this country by the name of

(D) The employment of indigo was strictly prohibited in England in the reign of Queen Elizabeth; nor was the prohibition taken off till the reign of Charles II. It was prohibited also in Saxony. In the edict it is spoken of as a corrosive substance, and called *food for the devil*. Colbert restricted the French dyers to a certain quantity of it.

(E) This will be described in a subsequent section.

of weld, is a plant which grows wild very commonly in Scotland, and in most European countries. Cultivated weld is a more slender stalk than the wild kind, but it is more valuable, because it is much more rich in colouring matter. It is an annual plant, of a yellowish green colour, furnished with a great number of small leaves. When ripe it is pulled, dried, tied up in parcels, and in that state sold to the dyer.

Weld readily yields its colouring matter to water. The saturated decoction of it is brown; but when sufficiently diluted with water it becomes yellow. Acids render its colour somewhat paler, but alkalies give it a deeper shade. When alum is added to it, a yellow coloured precipitate falls down, consisting of alumina combined with the colouring matter of weld. The affinity therefore of this colouring matter for alumina is so great, that it is able to abstract it from sulphuric acid. Its affinity for oxyd of tin is at least equally great; for muriat of tin causes a copious bright yellow precipitate, composed of the colouring matter and the oxyd combined. Most of the metallic salts occasion similar precipitates, but varying in colour according to the metal employed. With iron, for instance, the precipitate is dark grey, and with copper brownish green *.

423 Fustic. 2. The *morus tinctoria* is a large tree which grows in the West India islands. The wood of this tree is of a yellow colour, with orange veins. The French call it *yellow wood (bois jaune)*; but the English dyers have given it the absurd name of *old fustic* (F). This wood has been introduced into dyeing since the discovery of America. The precise time is not known; but that it was used in England soon after the middle of the 17th century, is evident from Sir William Petty's paper on *Dyeing*, read to the Royal Society soon after its institution. In that paper particular mention is made of *old fustic*.

Fustic gives out its colouring matter with great facility to water. The saturated decoction of it is of a deep reddish yellow colour; when sufficiently diluted it becomes orange yellow. Acids render it turbid, give it a pale yellow colour, and occasion a slight greenish precipitate, which alkalies redissolve. Alkalies give the decoction a very deep colour, inclining to red; some time after they have been added, a yellow matter separates from the liquid, and either swims on the surface, or adheres to the sides of the vessel. Alum, sulphat of iron, of copper, and of zinc, produce precipitates composed of the colouring matter combined respectively with the bases of these different salts; and the colour varies according to the substance with which this colouring matter is combined. With alumina it is yellow; with iron, yellowish brown; with copper, brownish yellow; and with zinc, greenish brown †.

† Ib. ii. 269.

424 Quercitron. 3. The *quercus nigra*, to which Dr Bancroft has given the name of *quercitron*, is a large tree which grows naturally in North America. Dr Bancroft discovered, about the year 1784, that the bark of this tree contains a great quantity of yellow colouring matter, and since that time it has been introduced into dyeing with much advantage. To prepare it for the dyer, the epidermis is shaved off, and then it is ground in a mill. It separates partly into stringy filaments, and partly into a fine light powder. Both of these contain colouring matter, and therefore are to be employed; but as they contain unequal quantities, they should be used in their natural proportions.

Quercitron bark readily gives out its colouring matter to water at the temperature of 100°. The infusion has a yellowish brown colour, which is rendered lighter by acids, and darker by alkalies. Alum occasions a scanty precipitate of a deep yellow colour; muriat of tin, a copious bright yellow precipitate; sulphat of tin, a dark olive precipitate; and sulphat of copper, a precipitate of a yellow colour inclining to olive ‡.

‡ Bancroft, i. 320.

425 Other yellow dyes. 4. Besides these dye stuffs there are others occasionally used by dyers. The following are the most remarkable:

Genista tinctoria, or *dyers broom*. This plant yields a very inferior yellow; it is only used for coarse woollen stuffs.

Serratula tinctoria, or *saw-wort*. This plant yields a yellow nearly of the same nature with *weld*; for which, therefore, it is a good substitute.

Juglans alba, or *American hiccory*. The bark of this tree yields a colouring matter exactly similar to that of quercitron bark, but much smaller in quantity.

Anotta is a name given to a red paste formed of the berries of the bixa orellana, a tree which is a native of America. This paste yields its colouring matter to a solution of alkali in water. The solution affords an exceedingly beautiful yellow dye, but very fading, and incapable of being fixed by any known mordant.

Turmeric is the root of the *curcuma longa*, a plant which grows both in the East and West Indies. It is richer in colouring matter than any other yellow dye stuff. It yields very beautiful yellows, but too fading to be of much use, and no mordant has any influence in contributing to their permanence.

426 Yellow requires a mordant. 5. Yellow colouring matters have too weak an affinity for cloth to produce permanent colours without the use of mordants. Cloth, therefore, before it be dyed yellow, is always prepared by combining some mordant or other with it. The mordant most commonly employed for this purpose is alumina. Oxyd of tin is sometimes used when very fine yellows are wanted. Tan is often employed as a subsidiary to alumina, in order to fix it more copiously on cotton and linen. Tartar is also used as an auxiliary to brighten the colour; and muriat of soda, sulphat of lime, and even sulphat of iron, in order to render the shade deeper.

6. The yellow dyed by means of fustic is more permanent, but not so beautiful as that given by weld or quercitron. As it is permanent, and not much injured by acids, it is often used in dyeing compound colours where

(F) The *rhus cotinus*, or Venice sumach, is a small shrub, formerly employed as a yellow dye, but now almost out of use. The French call it *fustet*, from which word it is probable, as Dr Bancroft supposes, that our dyers formed the term *fustic*. When the *morus tinctoria* was introduced as a dye-stuff, they gave it the same name: but in order to distinguish the two, they called the sumach, which was a small shrub, *young fustic*; and the morus, which was a large tree, *old fustic*. See Bancroft i. 312.

Yellow. where a yellow is required. The mordant is alumina. When the mordant is oxyd of iron, fustic dyes a good permanent drab colour.

Weld and quercitron bark yield nearly the same kind of colour; but as the bark yields colouring matter in much greater abundance, it is much more convenient, and, upon the whole, cheaper than weld. It is probable, therefore, that it will gradually supersede the use of that plant. The method of using each of these dye stuffs is nearly the same.

427 Method of inducing a yellow colour on wool, 7. Wool may be dyed yellow by the following process: Let it be boiled for an hour, or more, with about $\frac{1}{6}$th of its weight of alum, dissolved in a sufficient quantity of water. It is then to be plunged, without being rinced, into a bath of warm water, containing in it as much quercitron bark as equals the weight of the alum employed as a mordant. The cloth is to be turned through the boiling liquid till it has acquired the intended colour. Then a quantity of clean powdered chalk, equal to the hundredth part of the weight of the cloth, is to be stirred in, and the operation of dyeing continued for eight or ten minutes longer. By this method a pretty deep and lively yellow may be given fully as permanent as weld yellow *.

For very bright *orange*, or *golden yellows*, it is necessary to have recourse to the oxyd of tin as a mordant. A fine orange yellow may be given to woollen cloth, by putting, for every ten parts of cloth, one part of bark into a sufficient quantity of hot water; after a few minutes, an equal weight of murio-sulphat of tin is to be added, and the mixture well stirred. The cloth acquires the wished for colour in a few minutes when briskly turned in this bath †.

The same process will serve for producing *bright golden yellows*, only some alum must be added along with the tin. For the brightest golden yellow, the proportions sufficient for dyeing 100 parts of cloth are, 10 parts of bark, 7 parts of murio-sulphat of tin, and 5 parts of alum. All the possible shades of golden yellow may be given to cloth merely by varying the proportion of the ingredients according to the shade ‡.

In order to give the yellow that delicate *green* shade so much admired for certain purposes, the same process may be followed, only tartar must be added in different proportions according to the shade. Thus to dye 100 parts of cloth a *full bright yellow*, delicately inclining to *green*, 8 parts of bark, 6 of murio-sulphat, 6 of alum, and 4 of tartar, are to be employed. The tartar is to be added at the same time with the other mordants. If the proportion of alum and tartar be increased, the green shade is more lively: to render it as lively as possible, all the four ingredients ought to be employed in equal proportions. As these fine lemon-yellows are generally required only pale, 10 parts of each of the ingredients will be sufficient to dye about 300 parts of cloth §.

By adding a small proportion of cochineal, the colour may be raised to a fine orange, or even an aurora ‖.

428 Silk, 8. Silk may be dyed different shades of yellow, either by weld or quercitron bark, but the last is the cheapest of the two. The proportion should be from 1 to 2 parts of bark to 12 parts of silk, according to the shade. The bark, tied up in a bag, should be put into the dyeing vessel while the water which it contains is cold, and when it has acquired the heat of about 100°, the silk, previously alumed, should be dipped in, and continued till it assumes the wished for colour. When the shade required is deep, a little chalk or pearlash should be added towards the end of the operation. When a very lively yellow is wanted, a little murio-sulphat of tin should be added, but not too much, because tin always injures the glossiness of silk. The proportions may be 4 parts of bark, 3 of alum, and 2 of murio sulphat of tin ¶.

Silk is dyed fine orange and aurora colours by annotta. The process is merely dipping the silk into an alkaline solution of annotta. To produce the orange shade the alkali is saturated with lemon juice. The colours thus produced are exceedingly beautiful, but they want permanency.

429 [Cotton and linen.] 9. The common method of dyeing cotton and linen yellow, has been described in the article DYEING in the *Encyclopædia*. The cloth is first soaked in a solution of alum, and then dyed in a decoction of weld. After this it is soaked for an hour in a solution of sulphat of copper, and, lastly, it is boiled for an hour in a solution of hard soap. This process, besides the expence of it, is defective; because the yellow is neither so beautiful nor so permanent as it might be if the mordant were used in a different form.

The method recommended by Dr Bancroft is much more advantageous, yielding more permanent and beautiful colours at a smaller expence. The mordant should be acetite of alumina, prepared by dissolving 1 part of acetite of lead, and 3 parts of alum, in a sufficient quantity of water. This solution should be heated to the temperature of 100°, the cloth should be soaked in it for two hours, then wrung out and dried. The soaking may be repeated, and the cloth again dried as before. It is then to be barely wetted with lime water, and afterwards dried. The soaking in the acetite of alumina may be again repeated; and if the shade of yellow is required to be very bright and durable, the alternate wetting with lime water, and soaking in the mordant, may be repeated three or four times. By this contrivance a sufficient quantity of alumina is combined with the cloth, and the combination is rendered more permanent by the addition of some lime. The dyeing bath is prepared by putting 12 or 18 parts of quercitron bark (according to the depth of the shade required), tied up in a bag, into a sufficient quantity of cold water. Into this bath the cloth is to be put, and turned round in it for an hour, while its temperature is gradually raised to about 120°. It is then to be brought to a boiling heat, and the cloth allowed to remain in it after that only a few minutes. If it be kept long at a boiling heat the yellow acquires a shade of brown *.

Another way of dyeing cotton and linen very permanent yellows, would be to imitate the method adopted for dyeing cotton in the East. That method is indeed exceedingly tedious, but it might be very much shortened by carefully attending to the uses of the ingredients. The essential part of the process is to cause the alumina to combine in sufficient quantity with the cloth, and to adhere with sufficient firmness to ensure a permanent colour. This is accomplished by using three mordants; first oil, then tan, and lastly alum. The combination of these three substances produces a mordant which ensures a very permanent colour.

The cotton is first soaked in a bath composed of a sufficient quantity of oil, and mixed with a weak solution

* Bancroft, ii. 325.
† Ibid. 329.
‡ Ibid. 330.
§ Ibid.
‖ Ibid. 335.
¶ Bancroft, 345.
* Ibid. 351

Yellow.

tion of soda. Animal oil seems to answer best for the purpose. Vogler found that glue answered extremely well. The soda should be caustic: In that state it combines with the oil and enables the cloth to absorb it equally. It is then, after being washed, put into an infusion of nut galls (the whiter the better). The tan combines with the oil, while the gallic acid carries off the alkali that may remain attached to the cloth. The infusion ought to be hot; and the cotton, after coming out of it, should be dried as quickly as possible. Care should be taken that the quantity of galls do not exceed a just proportion compared with the oil, otherwise the colour will be darkened. The cotton, thus prepared, is to be put into a solution of alum. There is a strong affinity between tan and alumina; in consequence of which, the alum is decomposed, and the alumina combines with the tan in sufficient abundance †. The cotton, thus prepared, is to be dyed, as above described, with quercitron bark.

† *Chaptal, Ann de Chim.* xxvi. 251.

430 Chaptal's process for cotton.

Mr Chaptal, whose ingenious labours have contributed exceedingly to elucidate the theory of dyeing, has proposed an exceedingly simple and cheap method of dyeing cotton a fine permanent nankeen yellow. His process is as follows (G).

Cotton has so strong an affinity for oxyd of iron, that if put into a solution of that oxyd in any acid whatever, it decomposes the salt, absorbs the iron, and acquires a yellow colour. The cotton to be dyed is to be put into a cold solution of sulphat of iron, of the sp. gr. 1.020; it is then wrung out, and put directly into a ley of potass, of the sp. gr. 1.010, into which a solution of alum has been poured till it was saturated with it. After the cotton has remained in this bath four or five hours, it may be taken out, washed, and dried. By this process cotton may be dyed all the different shades of nankeen, by varying the proportion of the sulphat of iron. This colour has the advantage of not being injured by washing, and of being exceedingly cheap §.

§ *Ibid.* 270.

SECT. III. *Of Red.*

431 Red dyes.

THE principal colouring matters employed in dyeing *red* are, *kermes*, *cochineal*, *archil*, *madder*, *carthamus*, and *Brazil wood*.

432 Kermes.

1. In different parts of Asia and the south of Europe, there grows a small species of oak, to which Linnæus gives the name of *quercus coccifera*. On this oak resides a small insect, of a reddish brown colour; in commerce it is known by the name of *kermes*. This insect is a species of *coccus*: Linnæus called it *coccus ilicis*. These insects are gathered in the month of June, when the female, which alone is useful, is swelled with eggs. They are steeped for ten or twelve hours in vinegar to kill the young insects contained in the eggs, and afterwards dried on a linen cloth. In this state they are sold to the dyer.

Kermes readily gives out its colouring matter to water or alcohol. It was much used by the ancients in dyeing; the colours which it produced were highly esteemed, being inferior in price only to their celebrated purple. They gave it the name of *coccus*.

Red.

The colour which it communicates to cloth is exceedingly permanent, but being far inferior in beauty to those which may be obtained from cochineal, it has been but little employed by dyers since that splendid pigment came into common use.

433 Cochineal.

2. Cochineal is likewise an insect, a species of *coccus*. Linnæus distinguishes it by the name *coccus cacti*. It inhabits different species of cacti, but the most perfect variety is confined to the *cactus coccinillifer*. The cochineal insect was first discovered in Mexico; the natives had employed it in their red dyes before the arrival of the Spaniards. It became known in Europe soon after the conquest of Mexico; and the beauty of the colour which it communicates to cloth very soon attracted general attention. For many years it was mistaken for a vegetable production, as had been the case also with the kermes. Different accounts of its real nature had indeed appeared very early in the Philosophical Transactions; but the opinion of Pomet, who insisted that it was the seed of a particular plant, gained so much credit, that it was not entirely destroyed till the publication of Mr Ellis's paper in the 52d volume of the Philosophical Transactions, which established the contrary beyond the possibility of doubt.

The female cochineal insect remains like the kermes, during her whole life adhering to a particular spot of the tree on which it feeds. After fecundation, her body serves merely as a nidus for her numerous eggs, and gradually swells as these advance towards maturity. In this state the insects are gathered, put into a linen bag, which is dipt into hot water to destroy the life of the young animals contained in the eggs, and then dried. In this state they are sent to Europe and sold to the dyer.

The quantity of cochineal disposed of in Europe is very great. Bancroft informs us, that the Spaniards annually bring to market about 600,000 lbs. of it. Hitherto the rearing of the insects has belonged almost exclusively to that nation. Other nations have indeed attempted to share it with them, but without any remarkable success; as the Spaniards use every precaution to confine the true cochineal, and even the species of cactus on which it feeds, to Mexico. Mr Thiery de Menonville was fortunate enough to procure some specimens of both, and to transfer them in safety to St Domingo; but after his death, the insects were allowed to perish. The wild cochineal insect, which differs from the cultivated kind merely in being smaller, and containing less colouring matter, was produced in St Domingo, in considerable quantities, before the commencement of the present war. Several spirited British gentlemen have lately contrived to procure the insect; and vigorous efforts are making to rear it in the East Indies. We have not yet learned the success of these attempts; but we have reason to hope every thing from the zeal and abilities of those gentlemen who have taken an active part in the enterprize.

Cochineal readily gives out its colouring matter to water. The decoction is of a crimson colour, inclining to violet: It may be kept for a long time without putrifying or losing its transparency. Sulphuric acid gives

(G) We ought to mention, that this process, or at least one very similar, has been long well known to the calicoe printers of this country. Most of their brown yellows, or drabs, are dyed with iron.

Red.

gives it a red colour, inclining to yellow, and occasions a small fine red precipitate. Tartar gives it a yellowish red colour, which becomes yellow after a small quantity of red powder has subsided. Alum brightens the colour of the decoction, and occasions a crimson precipitate. Muriat of tin gives a copious fine red precipitate; sulphat of iron, a brownish violet precipitate; sulphat of zinc, a deep violate precipitate; acetite of lead, and sulphat of copper, violet precipitates †.

Water is not capable of extracting the whole of the colouring matter of cochineal; but the addition of a little alkali or tartar enables the water to extract the whole of it *.

434 Archil.

3. Archil (H) is a paste formed of the *lichen roccella*, pounded and kept moist for some time with stale urine. It gives out its colouring matter to water, to alcohol (I), and to a solution of ammonia in water.

The lichen roccella grows abundantly in the Canary islands, from which it is imported and sold to the dyers. Other lichens are likewise used to dye red, especially the *parellus*, from which the pigment called *litmus*, and by chemists *tursole*, is prepared; the *omphalodes* and *tartareus*, which are often employed in this country to dye coarse cloths. To these many others might be added; but the reader may consult the treatises of Hoffman and Westring on the subject.

435 Madder.

4. The *rubia tinctorum* is a small well known plant, cultivated in different parts of Europe for the sake of its roots, which are known by the name of *madder*. They are about the thickness of a goose quill, somewhat transparent, of a reddish colour, and a strong smell. They are dried, cleaned, ground in a mill, and in that state used by dyers.

Madder gives out its colouring matter to water. The infusion is of a brownish orange colour; alum produces in it a deep brownish red precipitate; alkaline carbonats, a blood red precipitate, which is redissolved on adding more alkali. The precipitate occasioned by acetite of lead is brownish red; by nitrat of mercury, purplish brown; by sulphat of iron, a fine bright brown. After the red colouring matter has been extracted from madder by water, it is still capable of yielding a brown colour ‡.

436 Carthamus.

5. *Carthamus tinctorius* is an annual plant, cultivated in Spain, Egypt, and the Levant, for the sake of its flowers, which alone are used in dyeing. After the juice has been squeezed out of these flowers, they are washed repeatedly with salt water, pressed between the hands, and spread on mats to dry. Care is taken to cover them from the sun during the day, and to expose them to the evening dews, in order to prevent them from drying too fast. Such is the method followed in Egypt.

The flowers of carthamus contain two colouring matters; a yellow, which is soluble in water, and a red, insoluble in water, but soluble in alkaline carbonats. The method of preparing them above described, is intended to carry off the yellow colouring matter, which is of no use, and to leave only the red. After the flowers are thus prepared, they are of a red colour, and have lost nearly one-half of their weight. An alkaline ley readily extracts their colouring matter, which may be precipitated by saturating the alkali with an acid. Lemon juice is commonly used for this purpose, because it does not injure the colour of the dye. Next to citric, sulphuric acid is to be preferred, provided too great a quantity be not used. The red colouring matter of carthamus, extracted by carbonat of soda, and precipitated by lemon juice, constitutes the *rouge* employed by the ladies as a paint. It is afterwards ground with a certain quantity of talc. The fineness of the talc, and the proportion of it mixed with the carthamus, occasion the difference between the cheaper and dearer kinds of *rouge*.

437 Brazil wood.

6. *Brazil wood*, or *fernambouc*, as it is called by the French, is the wood of the *cæsalpinia crispa*, a tree which grows naturally in America and the West Indian islands. It is very hard; its specific gravity is greater than that of water; its taste is sweetish: its colour, when fresh cut, is pale; but after exposure to the atmosphere, it becomes reddish.

Brazil wood yields its colouring matter to alcohol, and likewise to boiling water. The decoction is of a fine red colour. The mineral acids make it yellow, and occasion a reddish brown precipitate. Oxalic acid causes an orange red precipitate. Fixed alkali gives the decoction a crimson colour, inclining to brown; ammonia, bright purple. Alum occasions a copious crimson precipitate, especially if alkali is added at the same time. Sulphat of iron renders the decoction black. The precipitate produced by muriat of tin is rose coloured; that by acetite of lead of a fine deep red *.

The decoction of Brazil wood is fitter for dyeing after it has stood some time, and undergone a kind of fermentation.

438 Red requires a mordant.

7. None of the red colouring matters has so strong an affinity for cloth as to produce a permanent red, without the assistance of mordants. The mordants employed are alumina and oxyd of tin; oil and tan, in certain processes, are also used; and tartar and muriat of soda are frequently called in as auxiliaries.

8. Coarse woollen stuffs are dyed red with madder or

† Berthollet, ii. 173.

* Ibid 175. and Bancroft, i. 271.

‡ Berthollet, ii. 115.

* Berthollet, ii. 240.

(H) If we believe Tournefort, this dye stuff was known to the ancients. They employed it to dye the colour known by the name of *purple* of Amorgos, one of the Cyclades islands. If this account be accurate, the knowledge of it had been lost during the dark ages. It was accidentally discovered by a Florentine merchant about the year 1300, who observed, that urine gave a very fine colour to the lichen roccella. Mr Dufay discovered, that archil possesses the property of tinging indelibly white marble, of forming veins, and giving it the appearance of jasper. See *Mem. Par.* 1732.

(I) The tincture of archil is used for making *spirit of wine thermometers*. It is a singular fact, that this tincture becomes gradually colourless when excluded from the contact of air, and that it again recovers its colour when exposed to the atmosphere. The phenomenon was first observed by the Abbé Nollet, and described by him in an essay, published among the memoirs of the Academy of Sciences for 1742.

Red. or archil; but fine cloth is almost exclusively dyed with cochineal; though the colour which it receives from kermes is much more durable. Brazil wood is scarcely used, except as an auxiliary; because the colour which it imparts to wool is not permanent.

439 Wool how dyed crimson, Wool is dyed *crimson*, by first impregnating it with alumina by means of an alum bath, and then boiling it in a decoction of cochineal till it has acquired the wished-for colour. The crimson will be finer if the tin mordant be substituted for alum: indeed it is usual with dyers to add a little nitro-muriat of tin when they want fine crimsons. The addition of archil and potass to the cochineal, both renders the crimson darker and gives it more bloom; but the bloom very soon vanishes. For paler crimsons, one half of the cochineal is withdrawn, and madder substituted in its place.

440 And scarlet Wool may be dyed *scarlet*, the most splendid of all colours, by first boiling it in a solution of murio-sulphat of tin; then dyeing it pale yellow with quercitron bark, and afterwards crimson with cochineal: For scarlet is a compound colour, consisting of *crimson* mixed with a little *yellow*. This method was suggested by Dr Bancroft, who first explained the nature of the common method. The proportions which he gives are eight parts of murio-sulphat of tin for 100 parts of cloth. After the cloth has been boiled in this solution for a quarter of an hour, it is to be taken out, and about four parts of cochineal, and two and a half parts of quercitron bark, are to be thrown into the bath. After these are well mixed, the cloth is to be returned again to the bath, and boiled in it, till it has acquired the proper colour *.

* Bancroft, i. 291.

The common process for dyeing scarlet is as follows: Twelve parts of tartar are dissolved in warm water; then one part of cochineal is added, and soon after ten parts of nitro-muriat of tin. When the bath boils, 100 parts of cloth are put in, turned briskly through the bath, boiled in it for two hours; then taken out, aired, washed, and dried. Into another bath eleven parts of cochineal are put; and after its colouring matter is sufficiently extracted, 28 parts of nitro-muriat of tin are added. In this bath the cloth is boiled for an hour, and then washed and dried.

Every preceding writer on dyeing took it for granted, that the yellow tinge necessary for scarlet was produced by the nitro-muriat of tin, or rather by the nitric acid of that compound, and that the tartar was only useful in enlivening the colour. But Dr Bancroft ascertained, by actual experiment, that nitro-muriat of tin has no such effect; that cloth, impregnated with this or any other tin mordant, and afterwards dyed with cochineal, acquires only a crimson colour, unless tartar be added; that the tartar has the property of converting part of the cochineal to yellow; and therefore is the real agent in producing the scarlet colour. Good scarlet, indeed, cannot be made without tin; because every other mordant sullies the colour, and renders it dull †.

† Ibid. 288.

441 Red dyes employed for silk, 9. Silk is usually dyed red with cochineal or carthamus, and sometimes with Brazil wood. Kermes does not answer for silk; madder is scarcely ever used for that purpose, because it does not yield a bright enough colour. Archil is employed to give silk a bloom; but it is scarcely used by itself, unless when the colour wanted is lilac.

Silk may be dyed crimson by steeping it in a solution of alum, and then dyeing it in the usual way in a cochineal bath. But the common process is to plunge the silk, after it has been alumed, into a bath formed of the following ingredients: Two parts of white galls, three parts of cochineal, three-sixteenths of tartar, and three-sixteenths of nitro-muriat of tin, for every sixteen parts of silk. The ingredients are to be put into boiling water in the order they have been enumerated; the bath is then to be filled up with cold water; the silk put into it, and boiled for two hours. After the bath has cooled, the silk is usually allowed to remain in it for three hours longer. 442 In dyeing crimson,

The colours known by the names of poppy, cherry, rose, and flesh colour, are given to silk by means of carthamus. The process consists merely in keeping the silk, as long as it extracts any colour, in an alkaline solution of carthamus, into which as much lemon juice as gives it a fine cherry colour has been poured. To produce a deep poppy red, the silk must be put successively into a number of similar baths, and allowed to drain them. When the silk is dyed, the colour is brightened by plunging it into hot water acidulated with lemon juice. The silk ought to be previously dyed yellow with anotta. 443 Poppy,

Cherry red is produced the same way, only the anotta ground is omitted, and less colouring matter is necessary. When a flesh colour is required, a little soap should be put into the bath, which softens the colour, and prevents it from taking too quickly. 444 Cherry, 445 Flesh red,

To lessen the expence, some archil is often mixed with carthamus for dark shades.

The same shades may be dyed by means of brazil wood, but they do not stand.

Silk cannot be dyed a full scarlet; but a colour approaching to scarlet may be given it, by first impregnating the stuff with murio-sulphat of tin, and afterwards dyeing it in a bath composed of four parts of cochineal and four parts of quercitron bark. To give the colour more body, both the mordant and the dye may be repeated *. A colour approaching scarlet may be also given to silk, by first dyeing it crimson, then dyeng it with *carthamus*, and lastly yellow without heat. †. 446 Scarlet.

* Bancroft, i. 312.

† Berthollet, ii. 203.

10. Cotton and linen are dyed red with madder. The process was borrowed from the East; hence the colour is often called *Adrianople* or *Turkey red*. The cloth is first impregnated with oil, then with galls, and lastly with alum, in the manner described in the last section. It is then boiled for an hour in a decoction of madder, which is commonly mixed with a quantity of blood. After the cloth is dyed, it is plunged into a soda ley, in order to brighten the colour. The red given by this process is very permanent, and when properly conducted it is exceedingly beautiful The whole difficulty consists in the application of the mordant, which is by far the most complicated employed in the whole art of dyeing. 447 How to dye cotton and linen red.

Cotton may be dyed scarlet by means of murio-sulphat of tin, cochineal, and quercitron bark, used as for silk; but the colour is too fading to be of any value *.

* Bancroft, i. 316.

SECT. IV. *Of Black.*

1. The substances employed to give a black colour to cloth are red oxyd of iron and tan. These two sub- 448 Black dyes.
stances

Black. stances have a strong affinity for each other; and when combined, assume a deep black colour, not liable to be destroyed by the action of air and light. The affinity which each of them has for the different kinds of cloth has been already mentioned.

2. Logwood is usually employed as an auxiliary, because it communicates lustre, and adds considerably to the fulness of the black. It is the wood of the tree called by Linnæus *hæmatoxylum campechianum*, which is a native of several of the West India islands, and of that part of Mexico which surrounds the Bay of Honduras. It yields its colouring matter to water. The decoction is at first a fine red bordering on violet, but if left to itself it gradually assumes a black colour. Acids give it a deep red colour; alkalies a deep violet, inclining to brown. Sulphat of iron renders it as black as ink, and occasions a precipitate of the same colour. The precipitate produced by alum is dark red; the supernatent liquid becomes yellowish red *.

* Berthollet, ii. 255.

3. Cloth, before it receive a black colour, is usually dyed blue. This renders the colour much fuller and finer than it otherwise would be. If the cloth be coarse, the blue dye may be too expensive; in that case a brown colour is given by means of walnut peels.

449 How to induce a black on wool,

4. Wool is dyed black by the following process. It is boiled for two hours in a decoction of nut galls, and afterwards kept for two hours more in a bath composed of logwood and sulphat of iron, kept during the whole time at a scalding heat, but not boiled. During the operation it must be frequently exposed to the air; because the green oxyd of iron, of which the sulphat is composed, must be converted into red oxyd by absorbing oxygen, before the cloth can acquire a proper colour. The common proportions are five parts of galls, five of sulphat of iron, and 30 of logwood for every 100 of cloth. A little acetite of copper is commonly added to the sulphat of iron, because it is thought to improve the colour.

450 Silk,

5. Silk is dyed nearly in the same manner. It is capable of combining with a very great deal of tan; the quantity given is varied at the pleasure of the artist, by allowing the silk to remain a longer or shorter time in the decoction. After the galling, the silk is put into a solution of sulphat of iron, which is usually mixed with a certain quantity of iron filings and of gum. It is occasionally wrung out of the bath, exposed for some time to the air, and again immersed. When it has acquired a sufficiently full colour, it is washed in cold water, and afterwards steeped in a decoction of soap to take off the harshness, which silk always has after being dyed black.

451 Linen, and cotton.

6. It is by no means so easy to give a full black to linen and cotton. The cloth, previously dyed blue, is steeped for 24 hours in a decoction of nut galls. A bath is prepared, containing acetite of iron, formed by saturating acetous acid with brown oxyd of iron. Into this bath the cloth is put in small quantities at a time, wrought with the hand for a quarter of an hour, then wrung out and aired, again wrought in a fresh quantity of the bath, and afterwards aired. These alternate processes are repeated till the colour wanted is given. A decoction of alder bark is usually mixed with the liquor containing the nut galls.

It would probably contribute to the goodness and permanence of the colour, if the cloth, before being galled, were impregnated with oil, by being steeped in a mixture of alkaline ley and oil combined, as practised for dyeing cotton red.

own.

Sect. V. *Of Brown.*

That particular *brown* colour, with a cast of yellow, which the French call *fauve*, and to which the English writers on *dying* have appropriated the word *fawn*, though in fact a compound, is commonly ranked among simple colours; because it is applied to cloth by a single process. The substances employed to produce this colour are numerous; but we shall satisfy ourselves with enumerating the following:

Walnut peels are the green covering of the walnut. When first separated, they are white internally, but soon assume a brown, or even a black colour, on exposure to the air. They readily yield their colouring matter to water. They are usually kept in large casks, covered with water, for above a year, before they are used. To dye wool brown with them, nothing more is necessary than to steep the cloth in a decoction of them till it has acquired the wished-for colour. The depth of the shade is proportional to the strength of the decoction. The root, as well as the peel of the walnut tree, contains the same colouring matter, but in smaller quantity. The bark of the birch, also, and many other trees, may be used for the same purpose.

It is very probable, that the brown colouring matter is in these vegetable substances combined with tan. This is certainly the case in sumach, which is often employed to produce a brown. This combination explains the reason why no mordant is necessary; the tan has a strong affinity for the cloth, and the colouring matter for the tan. The dye stuff and the mordant are already, in fact, combined together.

Chap. V. Of Compound Colours.

Compound colours are produced by mixing together two simple ones; or, which is the same thing, by dyeing cloth first one simple colour, and then another. The result is a compound colour, varying in shade according to the proportions of each of the simple colours employed.

Compound colours are exceedingly numerous, varying almost to infinity, according to the proportions of the ingredients employed. They may be all arranged under the four following classes: 453 Division of compound colour.

Mixtures of 1. blue and yellow,
2. blue and red,
3. yellow and red,
4. black and other colours.

To describe all the different shades which belong to each of these classes, would be impossible; and even if it were possible, it would be unnecessary; because all the processes depend upon the principles laid down in the preceding chapters, and may easily be conceived and varied by those who understand these principles. In the following sections, therefore, it will be sufficient to mention the principal compound colours produced by the mixture of simple colours, and to exhibit a specimen or two of the mode of producing them.

Sect. I. *Of Mixtures of Blue and Yellow.*

The colour produced by mixtures of blue and yellow is

is green; which is distinguished by dyers by a great variety of names, according to the depth of the shade, or the prevalence of either of the component parts Thus we have *sea green, meadow* or *grass green, pea green*, &c. &c.

454 How induced 455 On wool Wool is usually dyed green by giving it first a blue colour, and afterwards dyeing it yellow; because, when the yellow is first given, several inconveniences follow: the yellow partly separates again in the blue vat, and communicates a green colour to it; and thus renders it useless for every other purpose, except dyeing green. Any of the processes for dyeing blue, described in the last chapter, may be followed; care being taken always to proportion the depth of the blue to the shade of green which is required. The cloth thus dyed blue may receive a yellow colour, by following the processes described in the last chapter for that purpose. When the sulphat of indigo is employed, it is usual to mix all the ingredients together, and to dye the cloth at once: the colour produced is known by the name of *Saxon*, or *English green*. One of the most convenient methods of conducting this process is the following:

Six or eight parts of quercitron bark, tied up in a bag, are to be put into the dyeing vessel, which should contain only a small quantity of warm water. When the water boils, six parts of murio sulphat of tin, and four parts of alum, are to be added. In a few minutes, the dyeing vessel should be filled up with cold water, till the temperature is reduced to about 130°. After this, as much sulphat of indigo is to be poured in as is sufficient to produce the intended shade of green. When the whole has been sufficiently stirred, a hundred parts of cloth are to be put in, and turned briskly for about fifteen minutes, till it has acquired the wished for shade *. By this method, a much more beautiful colour is obtained than is given by the usual process, in which fustic is employed to give the yellow shade.

456 Silk, Silk, intended to receive a green colour, is usually dyed yellow first, by means of weld, according to the process described in the last chapter; afterwards, it is dipped into the blue vat, and dyed in the usual manner. To deepen the shade, or to vary the tint, decoctions of logwood, anotta, fustic, &c. are added to the yellow bath. Or silk may be dyed at once green, by adding suitable proportions of sulphat of indigo to the common quercitron bark bath, composed of four parts of bark, three parts of alum, and two parts of murio sulphat of tin †.

457 Cotton, and linen. Cotton and linen must be first dyed blue, and then yellow, according to the methods described in the last chapter. It is needless to add, that the depth of each of these colours must be proportioned to the shade of green colour which it is the intention of the dyer to give.

* Bancroft, i. 336.

† Ibid. 346

SECT. II. *Of Mixtures of* BLUE *and* RED.

458 Violet, purple, lilac, THE mixture of blue and red produces *violet, purple*, and *lilac*, of various shades, and known by various names, according to the proportion of the ingredients employed. When the colour is deep, and inclines most to blue, it is called *violet*; but when the red is prevalent, it gets the name of *purple*. When the shade is light, the colour is usually called *lilac*. For violet, therefore, the cloth must receive a deeper blue; for purple, a deeper red; and for lilac, both of these colours must be light.

Wool is usually dyed first *blue*; the shade, even for violet, ought not to be deeper than that called *sky blue*; afterwards it is dyed scarlet, in the usual manner. The violets and purples are dyed first; and when the vat is somewhat exhausted, the cloth is dipped in which is to receive the lilac, and the other lighter shades. By means of sulphat of indigo, the whole process may be performed at once. The cloth is first alumed, and then dyed in a vessel, containing cochineal, tartar, and sulphat of indigo, in proportions suited to the depth of the colour required *. A violet colour may also be given to wool, by impregnating it with a mordant composed of tin dissolved in a mixture of sulphuric and muriatic acids, formed by dissolving muriat of soda in sulphuric acid: to which solution a quantity of tartar and sulphat of copper is added. The wool is then boiled in a decoction of logwood till it has acquired the wished for colour †.

Mixture of Blue and Red.

459 How induced on wool,

Silk is first dyed crimson, by means of cochineal, in the usual way, excepting only that no tartar, nor solution of tin, is employed: It is then dipped into the indigo vat till it has acquired the wished-for shade The cloth is often afterwards passed through an archil bath, which greatly improves the beauty of the colour. Archil is often employed as a substitute for cochineal: The silk first receives a red colour, in the usual way, by being dyed in an archil bath; afterwards it receives the proper shade of blue. The violet, or purple, given by this process is very beautiful, but not very lasting ‡. 460 Silk,

Silk may be dyed violet or purple at once, by first treating it with a mordant, composed of equal parts of nitro-muriat of tin and alum, and then dipping it into a cochineal bath, into which a proper quantity of sulphat of indigo has been poured. But this dye is fading; the blue colour soon decays, and the silk becomes red *.

Cotton and linen are first dyed blue, then galled, then soaked in a decoction of logwood; some alum and acetite of copper are added to the decoction, and the cloth is soaked again This process is repeated till the proper colour is obtained †. The colour produced by this method is not nearly equal in permanency to that described in this *Supplement* under the word IRON; to which we beg leave to refer the reader. The process there described has been long known; but Mr Chaptal has simplified it somewhat. 461 Cotton, and linen

* Poerner.

† Decroyzille. Berthollet, ii. 331.

‡ Berthollet, ii. 327.

* Gubliche Berthollet ii. 329.

† Berthollet ii. 337.

SECT. III. *Of Mixtures of* YELLOW *and* RED.

THE colour produced by the mixture of *red* and *yellow* is *orange*; but almost an infinity of shades results from the different proportions of the ingredients, and from the peculiar nature of the yellow employed. Sometimes *blue* is combined with red and yellow on cloth: the resulting colour is called *olive*. 462 Orange and olive

Wool may be dyed orange by precisely the same process which is used for scarlet, only the proportion of red must be diminished, and that of yellow increased. When wool is first dyed red with madder, and then yellow with weld, the resulting colour is called *cinnamon colour*. The mordant, in this case, is a mixture of alum and tartar. The shade may be varied exceedingly, by using other yellow dye stuffs instead of weld, and by varying the proportions, according to circumstances. Thus a reddish yellow may be given to cloth, by first dyeing it yellow, and then passing it through a madder bath. 463 How induced on wool,

Silk is dyed orange by means of carthamus: the method 464 Silk,

Mixtures of black with other Colours.

method has been deſcribed in the laſt chapter. Cinnamon colour is given to it by dyeing it, previouſly alumed, in a bath compoſed of the decoctions of logwood, Brazil wood, and fuſtic, mixed together.

Cotton and linen receive a cinnamon colour by means of weld and madder. The proceſs is complicated. The cloth is firſt dyed with weld and acetite of copper, then dipped in a ſolution of ſulphat of iron, then galled, then alumed, and then dyed in the uſual way with madder *.

For *olive*, the cloth is firſt dyed blue, then yellow, and laſtly paſſed through a madder bath. The ſhade depends upon the proportion of each of theſe colours. For very deep ſhades the cloth is alſo dipped into a ſolution of ſulphat of iron. Cotton and linen may be dyed *olive* by dipping them into a bath, compoſed of the decoction of four parts of weld and one of potaſs, mixed with the decoction of Brazil wood and a little acetite of copper †.

* *Berthollet*, ii. 344.

† *D'Apligny, ibid.* 345.

SECT. IV. *Of Mixtures of* BLACK *with other Colours.*

466
Greys, drabs, and browns.

STRICTLY ſpeaking, the mixtures belonging to this ſection are not mixtures of *black colours* with other colours, but combinations of the *black dye* with other colours; the ingredients of which, galls and brown oxyd of iron, being both mordants, variouſly modify other colouring matters by combining with them. Thus if cloth be previouſly combined with brown oxyd of iron, and afterwards dyed yellow with quercitron bark, the reſult will be a *drab* of different ſhades, according to the proportion of mordant employed. When the proportion is ſmall, the colour inclines to olive or yellow; on the contrary, the drab may be deepened or ſaddened, as the dyers ſpeak, by mixing a little ſumach with the bark *. The precautions formerly mentioned in applying the oxyd muſt be obſerved.

* *Bancroft*, i. 343.

It is very common to dip cloth already dyed ſome particular colour into a ſolution of ſulphat of iron, and galls or ſome other ſubſtance containing tan, called the *black bath*, in order to alter the ſhade, and to give the colour greater permanency. We ſhall give a few inſtances: greater minuteneſs would be inconſiſtent with the nature of this article.

Cloth dyed blue, by being dipped into the *black* bath, becomes *bluiſh grey*. Cloth dyed *yellow*, by the ſame proceſs, becomes *blackiſh grey*, *drab*, or *yellowiſh brown*. Cloth previouſly alumed, and dyed in a decoction of cochineal and acetite of iron, acquires a permanent *violet colour* inclining to *brown*, or a *lilac*, if the dyeing veſſel be ſomewhat exhauſted *. Cloth ſteeped in a mordant, compoſed of alum and acetite of iron diſſolved in water, and afterwards dyed in a bath compoſed of the decoction of galls and madder mixed together, acquires a fine deep *brown*. The method of varying the ſhades of linen and cotton will be readily conceived, after we have given an account of calico printing, which forms the ſubject of the next chapter.

* *Gubliche, Berthollet*, ii. 349.

CHAP. VI. OF CALICO PRINTING.

Calico Printing.

CALICO printing is the art of communicating different colours to particular ſpots or figures on the ſurface of cotton or linen cloth, while the reſt of the ſtuff retains its original whiteneſs.

467
Origin of calico printing.

This ingenious art ſeems to have originated in India, where we know it has been practiſed for more than 2000 years. Pliny indeed informs us, that the Egyptians were acquainted with calico printing; but a variety of circumſtances combine to render it more than probable that they borrowed it from India. The art has but lately been cultivated in Europe; but the enlightened induſtry of our manufacturers has already improved prodigiouſly upon the tedious proceſſes of their Indian maſters. No art has riſen to perfection with greater celerity: a hundred years ago it was ſcarcely known in Europe; at preſent, the elegance of the patterns, the beauty and permanency of the colours, and the expedition with which the different operations are carried on, are really admirable.

A minute detail of the proceſſes of calico printing would not only be foreign to the plan of this article, but of very little utility. To the artiſt the proceſſes are already known; an account of them therefore could give him no new information; while it would fatigue and diſappoint thoſe readers who wiſh to underſtand the principles of the art. We ſhall content ourſelves, therefore, with a ſhort view of theſe principles.

468
It conſiſts in applying mordants partially to cotton,

Calico printing conſiſts in impregnating thoſe parts of the cloth which are to receive a colour with a mordant, and then dyeing it as uſual with ſome dye ſtuff or other. The dye ſtuff attaches itſelf firmly only to that part of the cloth which has received the mordant. The whole ſurface of the cotton is indeed more or leſs tinged; but by waſhing it, and bleaching it for ſome days on the graſs with the wrong ſide uppermoſt, all the unmordanted parts reſume their original colour, while thoſe which have received the mordant retain it. Let us ſuppoſe, that a piece of white cotton cloth is to receive red ſtripes; all the parts where the ſtripes are to appear are penciled over with a ſolution of acetite of alumina. After this, the cloth is dyed in the uſual manner with madder. When taken out of the dyeing veſſel, it is all of a red colour; but by waſhing and bleaching, the madder leaves every part of the cloth white except the ſtripes impregnated with the acetite of alumina, which remain red. In the ſame manner, may yellow ſtripes, or any other wiſhed-for figure, be given to cloth, by ſubſtituting quercitron bark, weld, &c. for madder.

469
Which is afterwards dyed and bleached.

When different colours are to be given to different parts of the cloth at the ſame time, it is done by impregnating it with various mordants. Thus if ſtripes be drawn upon a cotton cloth with acetite of alumina, and other ſtripes with acetite of iron, and the cloth be afterwards dyed in the uſual way with madder and then waſhed and bleached, it will be ſtriped *red* and *brown*. The ſame mordants with quercitron bark give *yellow*, and *olive* or *drab*.

470
Mordants employed.

The mordants employed in calico printing are acetite of alumina and acetite of iron, prepared in the manner deſcribed in the third chapter of this part. Theſe mordants are applied to the cloth, either with a pencil or by means of blocks, on which the pattern, according to which the cotton is to be printed, is cut. As they are applied only to particular parts of the cloth, care muſt be taken that none of them ſpread to the part of the cloth which is to be left white, and that they do not interfere with one another when more than one are applied.

Calico Printing.

applied. If these precautions be not attended to, all the elegance and beauty of the print must be destroyed. It is necessary, therefore, that the mordants should be of such a degree of consistence that they will not spread beyond those parts of the cloth on which they are applied. This is done by thickening them with flour or starch when they are to be applied by the block, and with gum arabic when they are to be put on with a pencil. The thickening should never be greater than is sufficient to prevent the spreading of the mordants; when carried too far, the cotton is apt not to be sufficiently saturated with the mordant; of course the dye takes but imperfectly.

471 How applied.

In order that the parts of the cloth impregnated with mordants may be distinguished by their colour, it is usual to tinge the mordants with some colouring matter or other. The printers commonly use the decoction of Brazil wood for this purpose; but Bancroft has objected to this method, because he thinks that the Brazil wood colouring matter impedes the subsequent process of dyeing. It is certain, that the colouring matter of the Brazil wood is displaced during that operation by the superior affinity of the dye stuff for the mordant. Were it not for this superior affinity, the colour would not take at all. Dr Bancroft * advises to co[lour] the mordant with some of the dye stuff afterwards to be applied; and he cautions the using of more for that purpose than is sufficient to make the mordant distinguishable when applied to the cloth. The reason of this precaution is obvious. If too much dye be mixed with the mordant, a great proportion of the mordant will be combined with colouring matter; which must weaken its affinity for the cloth, and of course prevent it from combining with it in sufficient quantity to ensure a permanent dye.

* Bancroft, ii. 375.

Sometimes these two mordants are mixed together in different proportions; and sometimes one or both is mixed with an infusion of sumach or of nut galls. By these contrivances, a great variety of colours are produced by the same dye stuff.

472 Subsequent treatment of the cloth

After the mordants have been applied, the cloth must be completely dried. It is proper for this purpose to employ artificial heat; which will contribute something towards the separation of the acetous acid from its base, and towards its evaporation; by which the mordant will combine in a greater proportion, and more intimately with the cloth.

When the cloth is sufficiently dried, it is to be washed with warm water and cow dung, till all the flour or gum employed to thicken the mordants, and all those parts of the mordants which are uncombined with the cloth, are removed. The cow dung serves to entangle these loose particles of mordants, and to prevent them from combining with those parts of the cloth which are to remain white. After this the cloth is thoroughly rinsed in clean water.

473 Dye stuffs used.

Almost the only dye stuffs employed by calico printers are, indigo, madder, and quercitron bark or weld. This last substance, however, is now but little used by the printers of this country, except for delicate greenish yellows. The quercitron bark has almost superseded it; because it gives colours equally good, and is much cheaper, and more convenient, not requiring so great a heat to fix it. Indigo, not requiring any mordant, is commonly applied at once either with the block or a pencil. It is prepared by boiling together indigo, potash made caustic by quicklime, and orpiment: the solution is afterwards thickened with gum (x). It must be carefully secluded from the air, otherwise the indigo would soon be regenerated, which would render the solution useless. Dr Bancroft has proposed to substitute coarse brown sugar for orpiment. It is equally efficacious in decomposing the indigo and rendering it soluble; while it likewise serves all the purposes of gum *.

* Bancroft, i. 120.

When the cloth, after being impregnated with the mordant, is sufficiently cleansed, it is dyed in the usual manner. The whole of it is more or less tinged with the dye stuff. It is well washed, and then spread out for some days on the grass, and bleached with the wrong side uppermost. This carries the colour off completely from all the parts of the cotton which has not imbibed the mordant, and leaves them of their original whiteness, while the mordanted spots retain the dye as strongly as ever.

Let us now give an example or two of the manner in which the printers give particular colours to calicoes. Some calicoes are only printed of one colour, others have two, others three, or more, even to the number of eight, ten, or twelve. The smaller the number of colours, the fewer in general are the processes.

474 Method of printing drabs.

1. One of the most common colours on cotton prints is a kind of nankeen yellow, of various shades, down to a deep yellowish brown or drab. It is usually in stripes or spots. To produce it, the printers besmear a block, cut out into the figure of the print, with acetite of iron thickened with gum or flour; apply it to the cotton; which, after being dried and cleaned in the usual manner, is plunged

(x) Different proportions are used by different persons. Mr Hauffman mixes 25 gallons of water with 16 pounds of indigo well ground (or a greater or smaller quantity, according to the quality of the indigo and the depth of colour wanted); to which he adds 30 pounds of good carbonat of potash, placing the whole over a fire; and as soon as the mixture begins to boil, he adds, by a little at a time, 12 pounds of quick lime, to render the alkali caustic, by absorbing its carbonic acid. This being done, 12 pounds of red orpiment are also added to the mixture; which is then stirred, and left to boil for some little time, that the indigo may be perfectly dissolved; which may be known by its giving a yellow colour immediately upon being applied to a piece of white transparent glass. M. Oberkampf, proprietor of the celebrated manufactory at Jouy near Versailles, uses a third more of indigo; and others use different proportions, not only of indigo, but of lime, potash, and orpiment; which all seem to answer with nearly equal success: but with the best copper-coloured Guatamala indigo, it is certain that a good blue may be obtained from only half the quantity prescribed by Mr Hauffman, by using as much stone, or oyster shell lime, as of indigo, nearly twice as much potash, and a fourth part less of orpiment than of indigo. See *Bancroft*, I. 113.

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plunged into a potafs ley. The quantity of acetite of iron is always proportioned to the depth of the intended fhade.

475 Yellow, 2. For yellow, the block is befmeared with acetite of alumina. The cloth, after receiving this mordant, is dyed with quercitron bark, and then bleached.

476 Red, 3. Red is communicated by the fame procefs, only madder is fubftituted for the bark.

477 Blue, 4. The fine light blues, which appear fo often on printed cottons, are produced, by applying to the cloth a block befmeared with a compofition, confifting partly of wax, which covers all thofe parts of the cloth which are to remain white. The cloth is then dyed in a cold indigo vat; and after it is dry, the wax compofition is removed by means of hot water.

478 Lilac, brown, 5. Lilac, flea brown, and blackifh brown, are given by means of acetite of iron; the quantity of which is always proportioned to the depth of the fhade. For very deep colours, a little fumach is added. The cotton is afterwards dyed in the ufual manner with madder, and then bleached.

479 And dove. 6. Dove colour and drab, by acetite of iron and quercitron bark.

When different colours are to appear in the fame print, a greater number of operations are neceffary. Two or more blocks are employed, upon each of which

480 Application of different colours to the fame cloth. that part of the print only is cut which is to be of fome particular colour. Thefe are befmeared with different mordants, and applied to the cloth, which is afterwards dyed as ufual. Let us fuppofe, for inftance, that three blocks are applied to cotton; one with acetite of alumina, another with acetite of iron, a third with a mixture of thefe two mordants, and that the cotton is then dyed with quercitron bark, and bleached. The parts impregnated with the mordants would have the following colours.

Acetite of alumina, - - -	Yellow,
iron, - - -	Olive, drab, dove (L),
The mixture, - - - -	Olive green, olive.

If part of the yellow be covered over with the indigo liquor, applied with a pencil, it will be converted into *green*: By the fame liquid, blue may be given to fuch parts of the print as require it.

If the cotton be dyed with madder inftead of quercitron bark, the print will exhibit the following colours:

Acetite of alumina, - - -	Red,
iron, - - - -	Brown, black,
The mixture, - - - - -	Purple.

When a greater number of colours are to appear; for inftance, when thofe communicated by bark and thofe by madder are wanted at the fame time, mordants for part of the pattern are to be applied; the cotton is then to be dyed in the madder bath and bleached; then the reft of the mordants, to fill up the pattern, are added, and the cloth is again dyed with quercitron bark and bleached. This fecond dyeing does not much affect the madder colours; becaufe the mordants, which render them permanent, are already faturated. The yellow tinge is eafily removed by the fubfequent bleaching. Sometimes a new mordant is alfo applied to fome of the madder colours; in confequence of which they receive a new permanent colour from the bark. After the laft bleaching, new colours may be added by means of the indigo liquor. The following table will give an idea of the colours which may be given to cotton by thefe complicated proceffes.

I. *Madder dye.*	*Colours.*
Acetite of alumina, - - -	Red,
iron, - - - -	Brown, black,
Ditto diluted, - - - -	Lilac,
Both mixed, - - - - -	Purple.
II. *Bark dye.*	
Acetite of alumina, - - -	Yellow,
iron, - - - -	Dove, drab,
Lilac and acetite of alumina,	Olive,
Red and acetite of alumina,	Orange.
III. *Indigo dye.*	
Indigo, - - -	Blue,
Indigo and yellow - -	Green.

Thus no lefs than 12 colours may be made to appear together in the fame print by thefe different proceffes.

Thefe inftances will ferve to give the reader an idea of the nature of calico printing, and at the fame time afford an excellent illuftration of the importance of mordants in dyeing.

481 Colours for pencilling. If it were poffible to procure colours fufficiently permanent, by applying them at once to the cloth by the block or the pencil, as is the cafe with the mordants, the art of calico printing would be brought to the greateft poffible fimplicity: but at prefent this can only be done in one cafe, that of indigo; every other colour requires dyeing. Compofitions indeed may be made by previoufly combining the dye ftuff and the mordants. Thus *yellow* may be applied at once by employing a mixture of the infufion of quercitron bark and acetite of alumina; *red*, by mixing the fame mordant with the decoction of alumina, and fo on. Unfortunately the colours applied in this way are far inferior in permanency to thofe produced when the mordant is previoufly combined with the cloth, and the dye ftuff afterwards applied feparately. In this way are applied almoft all the fugitive colours of calicoes which wafhing or even expofure to the air deftroys.

As the application of colours in this way cannot always be avoided by calico printers, every method of rendering them more permanent is an object of importance. We fhall therefore conclude this chapter with a defcription of feveral colours of this kind propofed by Dr Bancroft, which have a confiderable degree of permanence.

A *yellow* printing colour may be formed by the following method: Let three pounds of alum, and three ounces of clean chalk, be firft diffolved in a gallon of hot water, and then add two pounds of fugar of lead; ftir this mixture occafionally during the fpace of 24 or 36 hours, then let it remain 12 hours at reft, and afterwards decant and preferve the clear liquor; this being

(L) According to the proportion of acetite of iron employed.

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ing done, pour so much more warm water upon the remaining sediment, as after stirring and leaving the mixture to settle will afford clear liquor enough to make, when mixed with the former, three quarts of this aluminous mordant or acetite of alumine. Then take not less than six, nor more than eight, pounds of quercitron bark properly ground; put this into a tinned copper vessel, with four or five gallons of clean soft water, and make it boil for the space of one hour at least, adding a little more water, if at any time the quantity of liquor should not be sufficient to cover the surface of the bark: the liquor having boiled sufficiently, should be taken from the fire, and left undisturbed for half an hour, and then the clear decoction should be poured off through a fine sieve or canvas strainer. This being done, let six quarts more of clear water be poured upon the same bark and made to boil ten or fifteen minutes, both having been first well stirred; and being afterwards left a sufficient time to settle, the clean decoction may then be strained off, and put with the former into a shallow wide vessel to be evaporated by boiling, until what remains, being joined to the three quarts of aluminous mordant before mentioned, and to a sufficient quantity of gum or paste for thickening, will barely suffice to make three gallons of liquor in the whole. It will be proper, however, not to add the aluminous mordant, until the decoction is so far cooled as to be but little more than blood warm; and these being thoroughly mixed by stirring, may afterwards be thickened by the gum of Senegal or by gum arabic, if the mixture is intended for penciling; or by a paste made with starch or flour, if it be intended for printing.

By substituting a pound of murio sulphat of tin for the aluminous mordant in the above composition, a mixture may be formed which affords a very bright and full yellow, of considerable durability.

Sulphat of tin, mixed with a decoction of quercitron bark, communicates to cotton a *cinnamon* colour, which is sufficiently permanent *.

When the decoctions of quercitron bark and logwood are boiled together, and suitable proportions of sulphat of copper and of verdigris are added to them, with a little carbonat of potash, a compound is formed, which gives a *green* colour to cotton. Bancroft has made trial of this; and though it has not fully answered his expectation, his attempts were attended with sufficient success to determine him to persevere in his experiments †.

If acetite of iron be mixed with a decoction of quercitron bark, and the mixture be properly thickened, the compound will communicate to cotton a *drab* colour of some durability. This compound, mixed with the olive colouring liquor above described, will produce an olive. If a solution of iron, by a diluted muriatic acid, or by a diluted nitric acid, be employed for this purpose instead of iron liquor, it will produce colours a little more lasting; but these solutions should be employed sparingly, that they may not hurt the texture of the linen or cotton to which they are intended to be applied.

* *Bancroft*, i. 400.

† *Ibid*, 402.

Subtriple ‖ Sulphuret.

SUBTRIPLE, is when one quantity is the 3d part of another; as 2 is subtriple of 6. And *Subtriple Ratio* is the ratio of 1 to 3.

SUBTRIPLICATE RATIO, is the ratio of the cube roots. So the subtriplicate ratio of a to b, is the ratio of $\sqrt[3]{a}$ to $\sqrt[3]{b}$, or of $a^{\frac{1}{3}}$ to $b^{\frac{1}{3}}$.

SUCCESSION OF SIGNS, in astronomy, is the order in which they are reckoned, or follow one another, and according to which the sun enters them; called also *consequentia*. As Aries, Taurus, Gemini, Cancer, &c.

SULPHURET OF LIME having lately been recommended by an eminent chemist * as a substitute for *potash* in the new method of bleaching, which, if it answer, may certainly be afforded at less expence, we shall here give the method of preparing the sulphuret.

* *W. Higgins*, M. R. I. A.

Take of sulphur, or brimstone in fine powder, four pounds; lime, well slaked and sifted, twenty pounds; water, sixteen gallons: these are all to be well mixed and boiled for about half an hour in an iron vessel, stirring them briskly from time to time. Soon after the agitation of boiling is over, the solution of the sulphuret of lime clears, and may be drawn off free from the insoluble matter which is considerable, and which rests upon the bottom of the boiler (A). The liquor in this state is pretty nearly of the colour of small beer, but not quite so transparent.

Sulphuret ‖ Sun.

Sixteen gallons of fresh water are afterwards to be poured upon the insoluble dregs in the boiler, in order to separate the whole of the sulphuret from them. When this clears (being previously well agitated), it is also to be drawn off and mixed with the first liquor; to these again thirty-three gallons more of water may be added, which will reduce the liquor to a proper standard for steeping the cloth.

Here we have (an allowance being made for evaporation, and for the quantity retained in the dregs) sixty gallons of liquor from four pounds of brimstone.

Although sulphur by itself is not in any sensible degree soluble in water, and lime but very sparingly so, water dissolving but about one seven hundredth part of its weight of lime; yet the sulphuret of lime is highly soluble.

When the above proportion of lime and sulphur is boiled with only twelve gallons of water, the sulphuret partly crystallizes upon cooling; and when once crystallized it is not easy of solution.

SUN (see ASTRONOMY-*Index*, Encycl.) is certainly that celestial body which, of all others, should most attract our attention. It has accordingly employed much of

(A) Although lime is one of the constituent principles of the sulphuret, yet being so intimately united to the sulphur it has no longer the property of lime; upon the same principle that sulphuric acid in sulphat of potash has not the property of that acid.

of the time and meditation, not only of the aſtronomer, but alſo of the ſpeculative philoſopher, in all ages of the world; and many hypotheſes have been formed, and ſome diſcoveries made, reſpecting the nature and the uſes of this vaſt luminary.

Sir Iſaac Newton has ſhewn, that the ſun, by its attractive power, retains the planets of our ſyſtem in their orbits: he has alſo pointed out the method whereby the quantity of matter which it contains may be accurately determined. Dr Bradley has aſſigned the velocity of the ſolar light with a degree of preciſion exceeding our utmoſt expectation. Gallileo, Scheiner, Hevelius, Caſſini, and others, have aſcertained the rotation of the ſun upon its axis, and determined the poſition of its equator. By means of the tranſit of Venus over the diſk of the ſun, our mathematicians have calculated its diſtance from the earth, its real diameter and magnitude, the denſity of the matter of which it is compoſed, and the fall of heavy bodies on its ſurface. We have therefore a very clear notion of the vaſt importance and powerful influence of the ſun on its planetary ſyſtem; but with regard to its internal conſtruction, we are yet extremely ignorant. Many ingenious conjectures have indeed been formed on the ſubject; a few of which we ſhall mention as an introduction to Dr Herſchel's, of which, as it is the lateſt, and perhaps the moſt plauſible, we ſhall give a pretty full account nearly in his own words.

The dark ſpots in the ſun, for inſtance, have been ſuppoſed to be ſolid bodies revolving very near its ſurface. They have been conjectured to be the ſmoke of volcanoes, or the ſcum floating upon an ocean of fluid matter. They have alſo been taken for clouds. They were explained to be opaque maſſes ſwimming on the fluid matter of the ſun, dipping down occaſionally. It has been ſuppoſed that a fiery liquid ſurrounded the ſun, and that by its ebbing and flowing the higheſt parts of it were occaſionally uncovered, and appeared under the ſhape of dark ſpots; and that by the return of the fiery liquid, they were again covered, and in that manner ſucceſſively aſſumed different phaſes. The ſun itſelf has been called a globe of fire, though perhaps metaphorically. The waſte it would undergo by a gradual conſumption, on the ſuppoſition of its being ignited, has been ingeniouſly calculated; and in the ſame point of view its immenſe power of heating the bodies of ſuch comets as draw very near to it has been aſſigned.

In the year 1779 there was a ſpot on the ſun which was large enough to be ſeen with the naked eye. By a view of it with a ſeven feet reflector, charged with a very high power, it appeared to be divided into two parts. The largeſt of the two, on the 19th of April, meaſured 1′ 8″.06 in diameter, which is equal in length to more than 31,000 miles. Both together muſt certainly have extended above 50,000. The idea of its being occaſioned by a volcanic exploſion violently driving away a fiery fluid, ought to be rejected (ſays Dr Herſchel) on many accounts. "To mention only one, the great extent of the ſpot is very unfavourable to ſuch a ſuppoſition. Indeed a much leſs violent and leſs pernicious cauſe may account for all the appearances of the ſpot. When we ſee a dark belt near the equator of the planet Jupiter, we do not recur to earthquakes and volcanoes for its origin. An atmoſphere, with its natural changes, will explain ſuch belts. Our ſpot on the ſun may be accounted for on the ſame principles. The earth is ſurrounded by an atmoſphere compoſed of various elaſtic fluids. The ſun alſo has its atmoſphere; and if ſome of the fluids which enter into its compoſition ſhould be of a ſhining brilliancy, in the manner that will be explained hereafter, while others are merely tranſparent, any temporary cauſe which may remove the lucid fluid will permit us to ſee the body of the ſun through the tranſparent ones. If an obſerver were placed on the moon, he would ſee the ſolid body of the earth only in thoſe places where the tranſparent fluids of our atmoſphere would permit him. In others, the opaque vapours would reflect the light of the ſun without permitting his view to penetrate to the ſurface of our globe. He would probably alſo find, that our planet had occaſionally ſome ſhining fluids in its atmoſphere; as, not unlikely, ſome of our northern lights might not eſcape his notice, if they happened in the unenlightened part of the earth, and were ſeen by him in his long dark night. Nay, we have pretty good reaſon to believe, that probably all the planets emit light in ſome degree; for the illumination which remains on the moon in a total eclipſe cannot be entirely derived from the light which may reach it by the refraction of the earth's atmoſphere. For inſtance, in the eclipſe of the moon October 22. 1790, the rays of the ſun refracted by the atmoſphere of the earth towards the moon, admitting the mean horizontal refraction to be 30′ 50″.8, would meet in a focus 189,000 miles beyond the moon; ſo that conſequently there could be no illumination from rays refracted by our atmoſphere. It is, however, not improbable, that about the polar regions of the earth there may be refraction enough to bring ſome of the ſolar rays to a ſhorter focus. The diſtance of the moon at the time of the eclipſe would require a refraction of 54′ 6″, equal to its horizontal parallax at that time, to bring them to a focus ſo as to throw light on the moon.

The unenlightened part of the planet Venus has alſo been ſeen by different perſons; and not having a ſatellite, thoſe regions that are turned from the ſun cannot poſſibly ſhine by a borrowed light; ſo that this faint illumination muſt denote ſome phoſphoric quality of the atmoſphere of Venus.

In the inſtance of the large ſpot on the ſun already mentioned, Dr Herſchel concludes, from appearances, that he viewed the real body of the ſun itſelf, of which we rarely ſee more than its ſhining atmoſphere. In the year 1783 he obſerved a fine large ſpot, and followed it up to the edge of the ſun's limb. Here he took notice that the ſpot was plainly depreſſed below the ſurface of the ſun, and that it had very broad ſhelving ſides. He alſo ſuſpected ſome part, at leaſt, of the ſhelving ſides to be elevated above the ſurface of the ſun; and obſerved that, contrary to what uſually happens, the margin of that ſide of the ſpot which was fartheſt from the limb was the broadeſt.

The luminous ſhelving ſide of a ſpot may be explained by a gentle and gradual removal of the ſhining fluid, which permits us to ſee the globe of the ſun. As to the uncommon appearance of the broadeſt margin being on that ſide of the ſpot which was fartheſt from the limb when the ſpot came near the edge of it, we may ſurmiſe that the ſun has inequalities on its ſurface, which Sun.

Sun.

may possibly be the cause of it. For when mountainous countries are exposed, if it should chance that the highest parts of the landscape are situated so as to be near that side of the margin or penumbra of the spot which is towards the limb, they may partly intercept our view of it when the spot is seen very obliquely. This would require elevations at least five or six hundred miles high; but considering the great attraction exerted by the sun upon bodies at its surface, and the slow revolution it has upon its axis, we may readily admit inequalities to that amount. From the centrifugal force at the sun's equator, and the weight of bodies at its surface, he computes, that the power of throwing down a mountain by the exertion of the former, balanced by the superior force of keeping it in its place of the latter, is near 6½ times less on the sun than on our equatorial regions; and as an elevation similar to one of three miles on the earth would not be less than 334 miles on the sun, there can be no doubt but that a mountain much higher would stand very firmly. The little density of the solar body seems also to be in favour of the height of its mountains; for, *cæteris paribus*, dense bodies will sooner come to their level than rare ones. The difference in the vanishing of the shelving side, instead of explaining it by mountains, may also, and perhaps more satisfactorily, be accounted for from the real difference of the extent, the arrangement, the height, and the intensity of the shining fluid, added to the occasional changes that may happen in these particulars during the time in which the spot approaches to the edge of the disk. However, by admitting large mountains on the face of the sun, we shall account for the different opinions of two eminent astronomers; one of whom believed the spots depressed below the surface of the sun, while the other believed them elevated above it. For it is not impossible that some of the solar mountains may be high enough occasionally to project above the shining elastic fluid, when, by some agitation or other cause, it is not of the usual height; and this opinion is much strengthened by the return of some remarkable spots which served Cassini to ascertain the period of the sun's rotation. A very high country, or chain of mountains, may oftener become visible, by the removal of the obstructing fluid, than the lower regions, on account of its not being so deeply covered with it.

In 1791 the Doctor examined a large spot on the sun, and found it evidently depressed below the level of the surface. In 1792 he examined the sun with several powers from 90 to 500, when it appeared evidently, that the black spots are the opaque ground, or body of the sun; and that the luminous part is an atmosphere, which, being interrupted or broken, gives us a transient glimpse of the sun itself. He perceived likewise, that the shining surface of the sun is unequal, many parts of it being elevated and others depressed; and that the elevations, to which Hevelius gave the name of *faculæ*, so far from resembling torches, were rather like the shrivelled elevations upon a dried apple, extended in length, and most of them joined together, making waves or waving lines. The faculæ being elevations, very satisfactorily explains the reason why they disappear towards the middle of the sun, and reappear on the other margin; for about the place where we lose them, they begin to be edgewise to our view; and if between the faculæ should lie dark spots, they will most frequently break out in the middle of the sun, because they are no longer covered by the side-views of these faculæ.

The Doctor gives a very particular account of all his observations, which seem to have been accurately made, and we need scarcely add with excellent telescopes. For that account, however, we must refer to the memoir itself, and hasten to lay before our readers the result of his observations. "That the sun (says he) has a very extensive atmosphere, cannot be doubted; and that this atmosphere consists of various elastic fluids, that are more or less lucid and transparent, and of which the lucid one is that which furnishes us with light, seems also to be fully established by all the phenomena of its spots, of the faculæ, and of the lucid surface itself. There is no kind of variety in these appearances but what may be accounted for with the greatest facility, from the continual agitation which, we may easily conceive, must take place in the regions of such extensive elastic fluids.

"It will be necessary, however, to be a little more particular as to the manner in which I suppose the lucid fluid of the sun to be generated in its atmosphere. An analogy that may be drawn from the generation of clouds in our own atmosphere, seems to be a very proper one, and full of instruction. Our clouds are probably decompositions of some of the elastic fluids of the atmosphere itself, when such natural causes, as in this grand chemical laboratory are generally at work, act upon them: we may therefore admit, that in the very extensive atmosphere of the sun, from causes of the same nature, similar phenomena will take place; but with this difference, that the continual and very extensive decompositions of the elastic fluids of the sun are of a phosphoric nature, and attended with lucid appearances, by giving out light.

"If it should be objected, that such violent and unremitting decompositions would exhaust the sun, we may recur again to our analogy, which will furnish us with the following reflections. The extent of our own atmosphere, we see, is still preserved, notwithstanding the copious decompositions of its fluids in clouds and falling rain; in flashes of lightning, in meteors, and other luminous phenomena; because there are fresh supplies of elastic vapours continually ascending to make good the waste occasioned by those decompositions. But it may be urged, that the case with the decomposition of the elastic fluids in the solar atmosphere would be very different, since light is emitted, and does not return to the sun, as clouds do to the earth when they descend in showers of rain. To which I answer, that, in the decomposition of phosphoric fluids, every other ingredient but light may also return to the body of the sun. And that the emission of light must waste the sun, is not a difficulty that can be opposed to our hypothesis: for as it is an evident fact that the sun does emit light, the same objection, if it could be one, would equally militate against every other assignable way to account for the phenomenon.

"There are, moreover, considerations that may lessen the pressure of this alleged difficulty. We know the exceeding subtilty of light to be such, that in ages of time its emanation from the sun cannot very sensibly lessen the size of this great body. To this may be added, that very possibly there may always be ways of restoration to compensate for what is lost by the emission

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fion of light, though the manner in which this can be brought about fhould not appear to us. Many of the operations of Nature are carried on in her great laboratory which we cannot comprehend, but now and then we fee fome of the tools with which fhe is at work. We need not wonder that their conftruction fhould be fo fingular as to induce us to confefs our ignorance of the method of employing them; but we may reft affured that they are not a mere *lufus naturæ*." Here he alludes to the great number of fmall telefcopic comets; which he fuppofes, as others had done before him, may be employed to reftore to the fun what had been loft by the emiffion of light. "My hypothefis, however, (continues he) does not lay me under any obligation to explain how the fun can fuftain the wafte of light. nor to fhew that it will fuftain it for ever; and I fhould alfo remark that, as in the analogy of generating clouds, I merely allude to their production as owing to a decompofition of fome of the elaftic fluids of our atmofphere, that analogy, which firmly refts upon the fact, will not be lefs to my purpofe, to whatever caufe thefe clouds may owe their origin. It is the fame with the lucid clouds, if I may fo call them, of the fun. They plainly exift, becaufe we fee them; the manner of their being generated may remain an hypothefis—and mine, till a better can be propofed, may ftand good; but whether it does or not, the confequences I am going to draw from what has been faid will not be affected by it."

Before he proceeds to draw thefe confequences, he informs us that, according to the above theory, a dark fpot in the fun is a place in its atmofphere, which happens to be free from luminous decompofitions; that faculæ are, on the contrary, more copious mixtures of fuch fluids as decompofe each other; and that the regions, in which the luminous folar clouds are formed, adding thereto the elevation of the faculæ, cannot be lefs than 1843, nor much more than 2765 miles in depth. It is true, continues he, that in our atmofphere the extent of the clouds is limited to a very narrow compafs; but we ought rather to compare the folar ones to the luminous decompofitions which take place in our *aurora borealis*, or luminous arches, which extend much farther than the cloudy regions. The denfity of the luminous folar clouds, though very great, may not be exceedingly more fo than that of our *aurora borealis*. For if we confider what would be the brilliancy of a fpace two or three thoufand miles deep, filled with fuch corrufcations as we fee now and then in our atmofphere, their apparent intenfity, when viewed at the diftance of the fun, might not be much inferior to that of the lucid folar fluid.

From the luminous atmofphere of the fun, he proceeds to its opaque body; which, by calculation from the power it exerts upon the planets, we know to be of great folidity; and from the phenomena of the dark fpots, many of which, probably on account of their high fituations, have been repeatedly feen, and otherwife denote inequalities in their level, we furmife that its furface is diverfified with mountains and valleys.

What has been faid, enables us to come to fome very important conclufions, by remarking, that this way of confidering the fun and its atmofphere removes the great diffimilarity we have hitherto been ufed to find between its condition and that of the reft of the great bodies of the folar fyftem.

The fun, viewed in this light, appears to be nothing elfe than a very eminent, large, and lucid planet, evidently the firft, or, in ftrictnefs of fpeaking, the only primary one of our fyftem, all others being truly fecondary to it. Its fimilarity to the other globes of the folar fyftem with regard to its folidity, its atmofphere, and its diverfified furface, the rotation upon its axis, and the fall of heavy bodies, leads us on to fuppofe that it is moft probably alfo inhabited, like the reft of the planets, by beings whofe organs are adapted to the peculiar circumftances of that vaft globe.

It may, however, not be amifs to remove a certain difficulty, which arifes from the effect of the fun's rays upon our globe. The heat which is here, at the diftance of 95 millions of miles, produced by their rays, is fo confiderable, that it may be objected, that the furface of the globe of the fun itfelf muft be fcorched up beyond all conception.

This may be very fubftantially anfwered by many proofs drawn from natural philofophy, which fhew that heat is produced by the fun's rays only when they act upon a calorific medium; they are the caufe of the production of heat, by uniting with the matter of fire which is contained in the fubftances that are heated; as the collifion of flint and fteel will inflame a magazine of gunpowder, by putting all the latent fire it contains into action. But an inftance or two of the manner in which the folar rays produce their effect, will bring this home to our moft common experience.

On the tops of mountains of a fufficient height, at an altitude where clouds can very feldom reach to fhelter them from the direct rays of the fun, we always find regions of ice and fnow. Now if the folar rays themfelves conveyed all the heat we find on this globe, it ought to be hotteft where their courfe is leaft interrupted. Again, our aëronauts all confirm the coldnefs of the upper regions of the atmofphere; and fince, therefore, even on our earth, the heat of any fituation depends upon the aptnefs of the medium to yield to the impreffion of the folar rays, we have only to admit, that on the fun itfelf, the elaftic fluids compofing its atmofphere, and the matter on its furface, are of fuch a nature as not to be capable of any exceffive affection from its own rays: and indeed this feems to be proved by the copious emiffion of them; for if the elaftic fluids of the atmofphere, or the matter contained on the furface of the fun, were of fuch a nature as to admit of an eafy chemical combination with its rays, their emiffion would be much impeded.

Our author then proceeds to fupport his theory by analogical reafonings; but as thefe will occur to fuch of our readers as are converfant with the fpeculations of aftronomers, we pafs on to his reflections upon the confequences of this theory. "That the ftars are funs can hardly admit of a doubt. Their immenfe diftance would perfectly exclude them from our view, if the light they fend us were not of the folar kind. Befides, the analogy may be traced much farther. The fun turns on its axis; fo does the ftar Algol; fo do the ftars called β Lyræ, δ Cephei, η Antinoi, ο Ceti, and many more; moft probably all. From what other caufe can we fo probably account for their periodical changes? Again,

our sun has spots on its surface; so has the star Algol, and so have the stars already noticed, and probably every star in the heavens. On our sun these spots are changeable; so they are on the star Ceti, as evidently appears from the irregularity of its changeable lustre, which is often broken in upon by accidental changes while the general period continues unaltered. The same little deviations have been observed in other periodical stars, and ought to be ascribed to the same cause. But if stars are suns, and suns are inhabitable we see at once what an extensive field for animation opens itself to our view.

"It is true, that analogy may induce us to conclude, that since stars appear to be suns, and suns, according to the common opinion, are bodies that serve to enlighten, warm, and sustain a system of planets, we may have an idea of numberless globes that serve for the habitation of living creatures. But if these suns themselves are primary planets, we may see some thousands of them with our own eyes, and millions by the help of telescopes, when at the same time the same analogical reasoning still remains in full force with regard to the planets which these suns may support."

The Doctor then observes, that from other considerations, the idea of suns or stars being *merely* the supporters of systems of planets, is not absolutely to be admitted as a general one. "Among the great number of very compressed clusters of stars I have given (says he) in my catalogues, there are some which open a different view of the heavens to us. The stars in them are so very close together, that, notwithstanding the great distance at which we may suppose the cluster itself to be, it will hardly be possible to assign any sufficient mutual distance to the stars composing the cluster, to leave room for crowding in those planets, for whose support these stars have been, or might be, supposed to exist. It should seem, therefore, highly probable, that they exist for themselves; and are, in fact, only very capital, *lucid*, primary planets, connected together in one great system of mutual support.

"The same remark may be made with regard to the number of very close double stars, whose apparent diameters being alike, and not very small, do not indicate any very great mutual distance: from which, however, must be deducted all those where the different distances may be compensated by the real difference in their respective magnitudes.

"To what has been said may be added, that, in some parts of the milky way, where yet the stars are not very small, they are so crowded, that in the year 1792, Aug. 22. I found by the gauges that, in 41 minutes of time, no less than 258,000 of them had passed through the field of view of my telescope.

"It seems, therefore, upon the whole, not improbable, that in many cases stars are united in such close systems as not to leave much room for the orbits of planets or comets; and that consequently, upon this account also, many stars, unless we would make them mere useless brilliant points, may themselves be lucid planets, perhaps unattended by satellites."

What a magnificent idea does this theory give of the universe, and of the goodness, as well as power, of its Author? And how cold must be that heart, and clouded that understanding, who, after the contemplation of it, can for one moment listen to the atheistical doctrines of those men who presume to account for all the phenomena of nature by chemical affinities and mechanical attraction? The man who, even in his heart, can say, that such an immense system, differing so widely in the structure of the different parts of it, but everywhere crowded with life, is the effect of unintelligent agency, is indeed, to use the emphatic language of an ancient astronomer—*a fool*.

Sunda
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Sutton.

SUNDA, Straits of, are formed by the approach of the south-east extremity of the island of Sumatra to the north west extremity of the island of Java (See these islands, *Encycl.*). The straits are interspersed with a number of small isles; the whole displaying a scenery scarcely to be exceeded in the softness, richness, and gaiety of its appearance. The two great islands, which are low, and in some places marshy near the shore, rise afterwards, in a gradual slope, towards the interior of the country, admitting in their ascent every variety of situation, and all the different tints of verdure. Of the smaller islands, a few have steep and naked sides, such as one in the middle of the strait, which the English navigators have distinguished, on that account, by the name of Thwart-the way, and two very small round ones, called, from their figures, the Cap and Button (see these islands, *Suppl.*); but most of the others are entirely level, founded upon beds of coral, and covered with trees. Some of these islands are surrounded with a white sandy beach, visited frequently by turtle; but most of them are adorned with thick shrubbery to the water's edge, the roots being washed by the sea, or the branches dipping into it; and on the outside are shoals, in which a multitude of little aquatic animals are busied in framing calcareous habitations for their residence and protection. Those fabrics gradually emerge above the surface of the water, and at length, by the adventitious adhesion of vegetable matter, giving birth to plants and trees, become new islands, or add to the size of those already produced by the same means. It is impossible not to be struck with the diversified operations of Nature for obtaining the same end, whether employed in originally fixing the granite foundation of the Brazils, or in throwing up, by some sudden and subsequent convulsion, the island of Amsterdam, or in continuing to this hour, through the means of animated beings, the formation of new lands in the Straits of Sunda. *Sir George Staunton's Account of the British Embassy to China.*

SUNNUD, a grant, patent, or charter, in Bengal.

SUPERPARTICULAR Proportion, or Ratio, is that in which the greater term exceeds the less by unit or 1. As the ratio of 1 to 2, or 2 to 3, or 3 to 4, &c.

SUPERPARTIENT Proportion, or Ratio, is when the greater term contains the less term once, and leaves some number greater than 1 remaining. As the ratio

of 3 to 5, which is equal to that of 1 to $1\frac{2}{3}$;

of 7 to 10, which is equal to that of 1 to $1\frac{3}{7}$; &c.

SUPPLEMENT, of an Arch or Angle, in geometry or trigonometry, is what it wants of a semicircle, or of 180°; as the *complement* is what it wants of a quadrant, or of 90°. So, the supplement of 50° is 130°; as the complement of it is 40°.

SUTTON (Thomas, Esq.), founder of the charter-house, was born at Knaith in Lincolnshire, in 1532, of an

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an ancient and genteel family. He was educated at Eton school, and probably at Cambridge, and studied the law in Lincoln's Inn; but this profession not suiting his disposition, he travelled into foreign countries, and made so long a stay in Holland, France, Spain, and Italy, as to acquire the languages of those various nations. During his absence, his father died, and left him a considerable fortune. On his return home, being a very accomplished gentleman, he became secretary to the earl of Warwick and his brother the earl of Leicester. By the former of these noblemen, in 1569, he was appointed master of the ordnance at Berwick; and distinguishing himself greatly in that situation, on the rebellion which at that time broke out in the north, he obtained a patent for the office of master general of the ordnance for that district for life. He is named as one of the chiefs of those 1500 men who marched into Scotland, by the order of Queen Elizabeth, to the assistance of the regent, the earl of Morton, in 1573; and he commanded one of the five batteries which obliged the strong castle of Edinburgh to surrender to the English. He purchased of the bishop of Durham the manors of Gateshead and Wickham; which, producing coal-mines, became to him a source of extraordinary wealth. In 1580, he was reputed to be worth L. 50,000

Soon after this, he married a rich widow, who brought him a considerable estate; and taking up the business of a merchant, riches flowed in to him with every tide. He is said to have had no less than thirty agents abroad. He was likewise one of the chief victuallers of the navy; and seems to have been master of the barque called Sutton, in the list of volunteers attending the English fleet against the Spanish armada. It is probable, also, that he was a principal instrument in the defeat of it, by draining the bank of Genoa of that money with which Philip intended to equip his fleet, and thereby hindering the invasion for a whole year. He is likewise said to have been a commissioner for prizes under Lord Charles Howard, High Admiral of England; and going to sea with letters of marque, he took a Spanish ship worth L. 20,000. His whole fortune, at his death, appears to have been in land L. 5,000 *per annum*; in money, upwards of L. 60,000; the greatest estate in the possession of any private gentleman till much later times He lived with great munificence and hospitality: but losing his lady in 1602, he retired from the world, lessened his family, and lived in a private frugal manner; and, having no issue, resolved to distinguish his name by some important charity. Accordingly, he purchased of the Earl of Suffolk Howard-House, or the late dissolved charter house, near Smithfield for the sum of L. 13,000, where he founded the present hospital, in 1611, for the relief of poor men and children. Before he had fixed upon this design, the court endeavoured to divert him from his purpose, and to engage him to make Charles I. then Duke of York his heir, by conferring on him a peerage; but being free from ambition, and now near his grave, the lustre of the coronet could not tempt him to change his plan. He died the 11th of December, 1611, at Hackney, aged 79. His body was conveyed, with the most solemn procession, to Christ church in London and there deposited, till 1614, when it was removed to the charter house, and interred in a vault on the north side of the chapel, under a magnificent tomb.

SUWOROW (A) RIMNIKSKI (Count Alexander), was a man so eminent in his profession, that, if war be an art founded on science, it would be improper not to give some account of his life in a Work of this nature. Various accounts of him, indeed, are already in the hands of the public; but they differ so much from one another in the pictures which they present of the *man*, that it is not easy, if it be always possible, to distinguish truth from falsehood. With respect to the talents of the *General*, there is not room for the same difference of representation; because a train of military successes, almost unrivalled, has rendered these conspicuous to all Europe. In the short detail that our limits permit us to give of the life of this singular man, we shall avail ourselves of all the information, public and private, which we have been able to obtain, and believe to be authentic; and we hope to make our readers acquainted with some particulars respecting his person and domestic habits which are not yet generally known.

The family of Suworow is said to have been from Sweden, and of a noble descent. The first of this name settled in Russia about the latter end of the last century; and having engaged in the wars against the Tartars and the Poles, were rewarded by the Czars of that period with lands and peasants. Basil, the father of our hero, is said to have been the godson of Peter the Great; to have been held in high estimation for his political knowledge and extensive erudition; and to have enjoyed, at his death, the two-fold rank of General and Senator *.

As this account is given by a man who professes to have formed an intimate acquaintance with Suworow himself, it ought to be correct; and yet we cannot help entertaining some doubts of its truth, or at least of its accuracy. It is well known, that extensive erudition was in no esteem in Russia at the period when Basil Suworow is here said to have been so learned; and it is likewise known, that if, by erudition, be meant a knowledge of ancient literature, it was even despised, at a much later period, by all who were at once noble, and possessed of lands and peasants (See RUSSIA, *Encycl.*). The truth is, as we have learned from unquestionable authority, that the family of Suworow was ancient and respectable; but being far from affluent, and their little property lying at the very extremity of the empire, we have reason to believe, that the subject of this memoir was the first of the family that ever was at court. Basil, however, if his ancestors were from Sweden, may have been free from the Russian prejudices against Greek and Latin; and this is the more probable, that he certainly gave a learned education to his son.

That son, Alexander Basilowitch Suworow, was according to the author already quoted, born in the year 1730;

(A) This name is spelled sometimes as we have spelled it, sometimes SUWARROW, and sometimes SUVOROFF. This last is according to the pronunciation; but we have adopted the orthography of the General himself, in his letter to Charette, the hero of Vendee.

1730: we have ſome reaſon to believe, that he was not born before 1732. His father had deſtined him, we are told, for the robe; but his early inclinations impelled him to the profeſſion of a ſoldier; and in 1742 he was enrolled as a fuſilier in the guards of Seimonow. He was afterwards a corporal, then a ſerjeant, and in 1754, he quitted the guards with the brevet of Lieutenant in the army. He made his firſt campaign in the ſeven years war againſt the Pruſſians, in the year 1759, entering upon actual ſervice under Prince Wolgonſki. As ſenior officer on duty, he attended on the commander in chief Count Fermor, who, admiring the conſummate reſolution which he appeared to poſſeſs, favoured him with his particular confidence. In 1761, he was ordered on ſervice in the light troops under General Berg; and with the rank of a field officer (we think that of Lieutenant colonel) he performed prodigies of valour, and exhibited much of that character which was afterwards ſo fully developed and diſplayed. Even then he ſeems to have formed the reſolution of dying on the field of battle rather than ſuffer himſelf to be taken priſoner; for when, with a handful of troops, he was once ſurrounded by a large detachment of Pruſſians, he determined to cut his way through them, or periſh in the attempt. In this daring enterpriſe he was not only ſucceſsful, but contrived to carry off with him twenty priſoners, though he was obliged to abandon two field-pieces, which he had a little before taken from a ſmaller detachment.

At the peace of 1762, he received from the Empreſs a colonel's commiſſion, written with her own hand; and being advanced, in 1768, to the rank of brigadier, he was, in the month of November, ordered to repair, with all poſſible ſpeed, to the frontiers of Poland. At that unfavourable ſeaſon, he croſſed rivers and moraſſes, whoſe paſſage was rendered more difficult by ſlight froſts; and, in the courſe of a month, traverſed 500 Engliſh miles, with the loſs of only a few men in the environs of Smolenſko.

The object of the Empreſs, at this time, was to ſubdue the Poliſh confederates, and to poſſeſs herſelf of certain provinces of that ill fated kingdom. How completely ſhe and her two allies, the Emperor of Germany and the King of Pruſſia, ſucceeded in their enterpriſe, has been related elſewhere (ſee POLAND, *Encycl.*). It is ſufficient, in this memoir, to obſerve, that the ſucceſſes of the Ruſſians were chiefly owing to the military ſkill and intrepidity of Suworow, who was their only active General, and was indeed, for four years, almoſt conſtantly employed in offenſive operations againſt the confederates. Not to mention the numerous actions and ſkirmiſhes of an inferior kind, in which his conduct and courage were always diſplayed, the victory at Stalovitz, over a ſuperior force, ably commanded, and the capture of Cracow, were alone ſufficient to intitle him to the character which he ever afterwards ſo well ſupported. The former of theſe drew the higheſt encomiums from the great Frederick of Pruſſia; and the latter decided the fate of Poland. It is proper to add, that Suworow, on theſe occaſions, did not tarniſh his laurels by unneceſſary cruelty. When a French officer, who ſurrendered at Cracow, offered him his ſword, according to the cuſtom of war, he refuſed it, ſaying, that he would not take the ſword of a brave man, whoſe maſter was not at war with his ſovereign; and, even to the leaders of the confederates, he granted better terms of capitulation than they had the preſumption to aſk.

In the year 1770, he had been promoted to the rank of Major general; and for his exploits in the Poliſh war, the Empreſs conferred upon him, at different times, the orders of St Ann, St George, and Alexander Newſky.

After performing ſome important ſervices on the frontiers of Sweden, Suworow received orders, in the beginning of 1773, to join the army in Moldavia, under the command of Field marſhal Romanzow; and there he began that glorious career, which ſoon made his name a terror to the Turks. His firſt exploit was the taking of Turtukey; of which he wrote the following laconic account to the commander in chief:

"Honour and glory to God! Glory to you, Romanzow! We are in poſſeſſion of Turtukey, and I am in it! "SUWOROW."

During the remainder of the war, which was of ſhort continuance, Suworow was conſtantly engaged, and conſtantly ſucceſsful. In the beginning of the year 1774, he was promoted to the rank of Lietenant-general; and on the 11th of June of the ſame year, he defeated the Turks in a great battle, in which they loſt 3000 men killed, ſome hundreds of priſoners, 40 pieces of artillery, and 80 ſtandards, with their ſuperb camp. Soon after this victory, peace was concluded between the two courts; and Lieutenant-general Suworow was ordered to proceed with all poſſible haſte to Moſcow, to aſſiſt in appeaſing the interior troubles of that part of the empire.

Theſe troubles were occaſioned by a Coſſac rebel, of the name of *Pugatchew*, or *Pugatcheff*, who, at the head of a party of his diſcontented countrymen, had long eluded the vigilance of Count Panin, the commander in chief in Muſcovy, and frequently cut off detachments of the army which were ſent out in queſt of him. The chace of Pugatcheff, for ſuch it may be called, was now wholly entruſted to the well-known activity of Suworow; and that General, after purſuing the rebel with inconceivable rapidity, through woods and deſerts, came up with him at a place called Urlaſk, and carried him priſoner to Count Panin, who ſent him to Moſcow, where he ſuffered the puniſhment due to his crimes. This inſurgent, it is ſaid, had at one time collected ſuch a force, and was followed with ſuch enthuſiaſm, that, if his underſtanding had been equal to his courage, and his moderation had kept pace with his power, he might have poſſeſſed himſelf of Moſcow, and made the Imperial Catharine tremble on her throne.

For ſeveral years after the taking of Pugatcheff, Suworow was employed in the Crimea, on the Cuban, and againſt the Nogay Tartars, in a kind of ſervice which, though it was of the utmoſt importance to the Empreſs, and required all the addreſs of the Lieutenant-general, furniſhed no opportunities for that wonderful diſplay of promptitude and reſource, which had characteriſed his more active campaigns. One incident, however, muſt be mentioned, even in this ſhort memoir, becauſe it ſhews the natural diſpoſition of the man. During the winter that Suworow paſſed among the Tartars, he was frequently viſited by the chiefs of that nation; and at one of theſe viſits, Mechmed Bay, the chief of the Gediſſens, often joked with Muſſa Bay, another chief, on his inclination to marry. Muſſa Bay

Suworow. was so extremely old, that Suworow thought the conversation ridiculous; and one day asked him, What ground Mechmed could have for such idle talk? Mussa replied, that Mechmed Bey was right; that he wished to marry; and that he hoped the General would make him a present of a beautiful Tartar girl of sixteen! Suworow immediately bought a young Tartar slave of a Cossac for 100 rubles, and sent her to Mussa Bey; who married her, lived with her a very few years, and died at the age of one hundred and eight! regretted, we are told, by the Lieutenant-general, who regarded him with great esteem and attachment.

In the end of the year 1786, Suworow was promoted to the rank of General in Chief; and, at the breaking out of the war with the Turks in 1787, he shewed how well he was intitled to that rank, by his masterly defence of Kinburn; a place of no strength, but of great importance, as it is situated at the mouth of the Dneiper, opposite to Oczakow. For the zeal and abilities which he displayed on this occasion, the Empress decorated him with the order of St Andrew; gave him six crosses of the order of St George, to be distributed, according to his judgment, among such of his officers as had most distinguished themselves; and, in a very flattering letter, regretted the wounds which he had received in defending the place.

At the siege of Oczakow, Suworow, who commanded the left wing of the army under Prince Potemkin, received a dangerous wound in the nape of the neck, which was followed by so smart a fever, that, for some time, his life was despaired of; but he persevered in his long accustomed practice of preferring regimen to medicine, and his health was gradually re-established. In the year 1789, he was appointed to the command of the army which was to co-operate with the Prince of Saxe Cobourg in Walachia; and, by marches of inconceivable rapidity, he twice, in the space of two months, preserved the army of that Prince from inevitable destruction. Putting himself at the head of 8000 Russians, and literally running to the aid of his ally, he came up with the Turks in time to change the fate of the day at the battle of Forhani, which was fought on the 21st of July; and again at Rymnik, which, with 7000 men, he had reached with equal celerity, he gained, on the 22d of September, in conjunction with the Prince, one of the greatest victories that have ever been atchieved. According to the least exaggerated account, the Turkish army, commanded by the Grand Visier in person, amounted to 90,000 or 100,000 men; of which 70,000 were chosen troops: whilst the army of the allies exceeded not 25,000. At the commencement of the attack, Suworow, who had reconnoitered the country, and formed the plan of the battle, called out to his Russians, "My friends, look not at the eyes of your enemies, but at their breasts; it is there that you must thrust your bayonets." No quarter was given to the Turks; and on this account the Russian General has been charged with savage ferocity: but the charge, if not groundless, must be shared equally between him and the Prince of Cobourg. The commanders of the allied army, aware of the immense superiority of their enemies, had resolved, before the engagement, not to encumber themselves with prisoners, whom they could not secure without more than hazarding the fate of the day: And where is the man, who admits the lawfulness of war, that will condemn such conduct in such critical circumstances?

The taking of Bender and Belgrade were the immediate consequences of the victory of Rymnik; and so sensible was the Emperor Joseph how much the rapid movements and military skill of Suworow had contributed to that victory, that he immediately created him a Count of the Roman empire, and accompanied the diploma with a very flattering letter. Similar honours were conferred upon him by his own sovereign, who sent him the diploma of Count of the empire of Russia, with the title of Rymnikski, and the order of St Andrew of the first class.

In the autumn of 1790, Prince Potemkin wrote to Count Suworow, requesting a particular conference. The General, who conjectured the object of it, sent him the following answer: "The flotilla of row-boats will get possession of the mouths of the Danube; Tulcia and Isaccia will fall into our power; our troops, supported by the vessels, will take Ismailow and Brahilow, and make Tchistow tremble." He was perfectly right in his conjecture: it was to concert with him measures for the taking of Ismailow that the Prince had requested the conference. He did not, however, receive orders to undertake that desperate enterprise till the beginning of November, when he rapidly approached towards that fortress. His army, by sea and land, consisted of 23,000 men; of whom one-half were Cossacs, and of these many were sick. The troops of the garrison, which were under the orders of seven Sultans, amounted to 43,000 men, of whom nearly one half were Janissaries; the fortress was by much the strongest of any on the Turkish frontier; it was under the command of an old warrior, who had twice refused the dignity of Grand Visier, and had displayed against the Austrians considerable abilities, as well as the most intrepid courage; and the Grand Seignior had published a firman, forbidding the garrison, on pain of death without trial, to surrender on any terms whatever.

Potemkin, knowing that Suworow had with him no battering cannon, and dreading the consequences of a repulse, wrote to the General, that if he was not certain of success, he would do well not to risk an assault. The laconic reply was; "My plan is fixed. The Russian army has already been twice at the gates of Ismailow; and it would be shameful to retreat from them the third time without entering the place." To spare the effusion of blood, however, if possible, he sent a note to the Seraskier who commanded in Ismailow, to assure him, upon Count Suworow's word of honour, that if he did not hang out a white flag that very day, the place would be taken by assault, and all the garrison put to the sword. The Seraskier returned no answer to the note; but another commander was pleased to say, that "The Danube would cease to flow, or the heavens bow down to the earth, before Ismailow would surrender to the Russians!"

Having concerted with the Admiral proper measures for the assault, Suworow passed the night, with some officers of his suite, in impatient vigilance for the appointed hour when the signals were to be given. These were the firing of a musket at three, four, and five in the morning, when the army rushed upon the place; and notwithstanding the desperate opposition of the Turks, the depth of the moat, and the height of the ramparts,

ramparts, they were completely masters of Ismailow by four o'clock P. M. In this one dreadful day the Ottomans lost 33,000 men killed or dangerously wounded; 10,000 who were taken prisoners; besides 6000 women and children, and 2000 Christians of Moldavia, who fell in the general massacre. The place was given up to plunder for three days, according to agreement with the army before the assault; but we have authority to say, that no person was murdered in cold blood, who did not prefer his property to his life.

The Russians found in Ismailow 232 pieces of cannon, many large and small magazines of gunpowder, an immense quantity of bombs and ball, 345 standards almost all stained with blood, provisions for the Turkish army for six months, and about 10,000 horses, of which many were extremely beautiful. Suworow, who was inaccessible to any views of private interest, did not appropriate to himself a single article, not so much as a horse; but having, according to his custom, rendered solemn thanks to God for his victory, wrote to Prince Potemkin the following Spartan letter: "The Russian colours wave on the ramparts of Ismailow."

Peace being concluded with the Turks in December 1791, no political events occurred from that period to call forth the military talents of Suworow till 1794. In the beginning of that year mutinies having broken out among the Polish troops in the service of Russia, and the Empress, with her two potent allies, having digested the plan for the partition of Poland, Count Suworow received orders, in the month of May, to proceed, by forced marches, into Red Russia, with a corps of 15,000 men, and to disarm all the Polish troops in that province. This service he performed without the effusion of blood, disarming in less than a fortnight 8000 men, dispersed over a country of 150 miles in circuit. Soon afterwards he was ordered to march into the interior of Poland; the King of Prussia having been obliged to raise the siege of Warsaw, and the Empress perceiving that more vigorous measures than had hitherto been pursued, were necessary to accomplish her designs.

To give a detailed account of his route to Warsaw, would be to write the history of the Polish war, and not the memoirs of Count Suworow. It has been rashly supposed, that he had to contend only with raw troops, commanded by inexperienced leaders, who were not cordially united among themselves; but the fact is otherwise, and Suworow never displayed greater resource in the day of danger, than in the numerous battles and skirmishes in which he was engaged on his march to the capital of Poland. At last, after surmounting every obstacle, he sat down, on the 22d of October, before Praga, a strongly fortified suburb of Warsaw, defended by a formidable artillery, and a garrison of 30,000 men, rendered desperate by their situation. The Russian army exceeded not 22,000; and with that comparatively small force he resolved to storm Praga, as he had stormed Ismail. Having erected some batteries to deceive the garrison into a belief that they were to be regularly besieged, he concerted with the other Generals the mode of assault; and when every thing was ready, he gave his orders in these words: "Storm, and take the batteries, and cut down all who resist; but spare the inhabitants, unarmed persons, and all who shall ask for quarter."

There are but few examples of a military operation so boldly conceived, so skilfully performed, or so important in its consequences, as the taking of Praga. The assault was made at once in seven different places at five in the morning; and at nine the Russians were masters of the place, having penetrated by pure force a triple entrenchment. Of the Poles 13,000 lay dead on the field of battle, one third of whom were the flower of the youth of Warsaw; above 2000 were drowned in the Vistula; and 14,080 were taken prisoners, of whom 8000 were disarmed and immediately set at liberty, and the remainder the next day. We mention these circumstances, because they completely refute the tales of those Jacobin scribblers, who have so strenuously endeavoured to tarnish the laurels of the Russian hero, by representing him as having ordered a general massacre of men, women, and children. The artillery taken from the enemy consisted of 104 pieces of cannon and mortars, chiefly of large calibre. The Russians had 580 men killed, of whom eight were superior and staff-officers, and 900 wounded, of whom 23 were officers. Suworow.

Soon after the storming of Praga, Warsaw capitulated, and Suworow was received into the city by the magistrates in a body, and in their ceremonial habits. When the president presented to him the keys of the city, he pressed them to his lips, and then, holding them up towards heaven, he said, "Almighty God, I render thee thanks, that I have not been compelled to purchase the keys of this place as dear as . . . . ." Turning his face towards Praga, his voice failed him, and his cheeks were instantly bathed with tears. As he rode through the streets, the windows were filled with spectators, who were delighted with the return of order, and the assurance of peace; and the air resounded with the exulting exclamations of "Long live Catharine! Long live Suworow!"

Thus did Count Suworow, in the course of a very few months, overturn the kingdom and republic of Poland. It is not our business, in this article, to decide on the justice of the cause in which he was embarked. Of the Polish revolution, which gave rise to the war that subverted the republic, and swept it from the number of sovereign states, the reader will find some account under the title POLAND in the *Encyclopædia*; but it is here proper to acknowledge, that we do not now think so favourably, as when we wrote that article, of the views and principles of those who framed the constitution, which brought upon them the Russian and Prussian arms. Subsequent events seem to have proved completely, that if Poland had not been conquered by the allied powers, it would soon have been involved, under Kosciusko and his Jacobinical adherents, in all the horrors of revolutionary France; and the unhappy king, instead of being carried captive into Russia, would probably have finished his course on a scaffold. Suworow, who never concerned himself with the intrigues of courts, and expressed on all occasions the most sovereign contempt of those Generals who affected to possess the secrets of statesmen, probably never enquired into the final object of the war, but thought it his duty to execute, in his own sphere, the orders of his Imperial mistress. So sensible was Catharine of the propriety of this conduct, and of the zeal and abilities which he had displayed in the Polish campaign, that immediately on receiving accounts of the storming of

Suworow. Praga and the ſubmiſſion of Warſaw, ſhe announced to him, in a letter written with her own hand, his well-earned advancement to the rank of Field-marſhal General. Nor did her munificence ſtop there: She loaded him with jewels, and preſented him with an eſtate of 7000 peaſants, in the diſtrict of Kubin, which had been the ſcene of his firſt battle in the courſe of the campaign.

From the ſubjugation of Poland we hear little more of Field marſhal Suworow till he entered upon his glorious career in Italy. He is ſaid, indeed, to have given offence to the preſent Emperor ſoon after his acceſſion to the throne, by affording protection to ſome meritorious officers, whom his Majeſty had in an arbitrary manner diſmiſſed from the ſervice; but that offence was overlooked, and Suworow called again into action, when Paul joined the coalition againſt France.

Of the exploits of the Field marſhal in Italy, where, to uſe his own words, he deſtroyed armies and overturned ſtates, we have given a full account under the title Revolution in this *Supplement*. In his former campaigns, the wiſdom of his meaſures, the diſtribution of his forces, the undaunted character of his operations, and the progreſſive continuance of his ſucceſs, furniſh proofs of the ſuperiority of his talents hardly to be paralleled in the annals of modern war; but, animated by the nobleneſs of his cauſe, and confiding, as he ſaid, in the God of battles, he ſeems in his laſt campaign to have ſurpaſſed himſelf (B). It would appear, however, that his own Sovereign thought otherwiſe; and if he did, he was certainly as ſingular in that opinion as he is ſaid to be in many others. Conſidering the Field-marſhal as the conqueror of Italy, he had indeed created him a Prince by the ſtyle and title of Prince Suworow-*Italiſki*; but how did he receive him, when he returned into the Ruſſian dominions at the head of his veteran and victorious bands?

Though the old warrior thought himſelf almoſt betrayed at the end of the campaign by the crooked policy of the court of Vienna, he doubtleſs hoped to be received at the court of St Peterſburgh, if not with triumphal arches, at leaſt with the moſt public teſtimo-

(B) Were any other proof than a ſimple narrative of his ſucceſs neceſſary to evince the abilities diſplayed by Marſhal Suworow in the laſt campaign, that proof might be found in the ſad reverſes of the preſent. At the opening of the campaign of 1800, the allies poſſeſſed infinitely greater advantages over the enemy than at the beginning of the campaign of 1799; and we ventured to ſay, towards the end of the article Revolution, in this *Supplement*, that the affairs of the French ſeemed in Italy to be deſperate. But how egregiouſly have we been miſtaken? By the moſt unaccountable infatuation, the Auſtrian commander in Italy would not *believe* that the French army of reſerve, which was advancing upon him with the uſual celerity of the Firſt Conſul's movements, conſiſted of more than *ſix thouſand men!* Inſtead therefore of marching rapidly to meet them before they could be wholly diſentangled from the paſſes over the Alps, he waited patiently for them in the plains of Marengo. If we may judge of the future by the paſt, we may ſurely ſay that ſuch would not have been the conduct of Suworow. Even after the two hoſtile armies met, and fought, on the 10th of July, one of the bloodieſt battles of the preſent war, the ſucceſs of the French was not ſuch as to intitle them to the acquiſitions which were the conſequence of their dear-bought victory. The fate of the day was long doubtful; and it was at laſt decided, not by any extraordinary exertions of the Conſul, but partly by the provident conduct of General Deſſaix, who, with the aid of freſh troops, erected a new battery at a critical point, and at a critical period; and ſtill more by the ſituation of General Melas, whoſe faculties, though frequently ſupported by wine and ſpirits, are ſaid to have wholly forſaken him in the latter part of the day. When he was in this ſtate, one falſe movement, which weakened his centre, afforded an opportunity to Deſſaix to make a vigorous and ſucceſsful charge with a body of cavalry that had not yet been engaged.

But even after this defeat, what was the ſtate of the two armies? The Auſtrians had loſt 6000 men, and the French from 12,000 to 14,000: the former, enraged at having had the victory ſo wreſted out of their hands, were eager to renew the conteſt on the following day; and the latter had obtained only the barren advantage of keeping poſſeſſion of the field of battle. In ſuch a ſituation, Suworow would certainly have encouraged the ardour of his men; but the Auſtrian commander, who complained laſt year of the Field-marſhal for being too little ſparing of blood, inſtead of following the example which he had ſet him at the battle of Trebia, concluded a capitulation unparalleled, we believe, in the annals of war; a capitulation by which he voluntarily ſurrendered into the hands of the enemy nearly all the fruits of one of the moſt glorious campaigns recorded in hiſtory. We wiſh not to throw any undue aſperſion upon the character of General Melas: We believe him to be a brave man, and ſuch he has been repreſented to us in various accounts which we have had directly from Germany; but all theſe accounts agree in repreſenting him likewiſe as fit, not to have the ſupreme command of a great army, but only to execute the orders of a ſuperior mind.

In Germany, the gallant Kray has been obliged to retreat before the equally gallant Moreau; but he has wiſely not hazarded the conſequences of a general action. We ſay *wiſely*; becauſe we have learned from authority which we cannot queſtion, that his army is in a ſtate little better than that of mutiny. To his officers he is in a great meaſure a ſtranger; and therefore theſe gentlemen think themſelves at liberty to diſobey his orders! What the conſequence of all this will be, it becomes not us to conjecture. An armiſtice has in the mean time * taken place both in Italy and in Germany; and it is not impoſſible that the Aulic Council, aided by the mob of Vienna, may induce the Emperor to make a ſeparate peace.—We need hardly make an apology for the length of this note, which our readers will conſider as a continuation, the lateſt that we ſhall have an opportunity to give, of the progreſs of the French revolution, which we once flattered ourſelves would, by this time, have taken a very different turn; and a different turn it would have taken if another Suworow had commanded in Italy.

* September the 4th 1800.

Suworow. nies of his Sovereign's approbation. It is said, that he expected to be sent back at the head of a large army, with full powers to act as he should judge proper for bringing the war to a happy termination, and restoring peace and order to Europe; and he certainly expressed, in letters to different correspondents, his earnest wish to conclude his military career with contributing to the accomplishment of so desirable an object. What then must have been his disappointment, when the Russian Emperor would not see him, and positively forbad his appearance at court? To the messenger who brought the order, the Field-marshal gave a purse of money, turned his carriage another way, and drove to a wooden house, at a distance from the court, and from his former friends, "where burst his mighty heart;" and the conqueror of the Turks, the Poles, and the French republicans, died, almost unattended, on the 18th of May 1800. The sovereign, who thus disgraced him at the end of his life, gave him a magnificent funeral!

In his person Suworow was tall, considerably exceeding six feet, and full chested. His countenance was stern; but among his friends his manners were pleasant, and his dispositions were kind. His temper was naturally violent; but that violence he constantly laboured to moderate, though he was never able completely to extinguish it. According to M. Anthing, an effervescent spirit of impatience predominated in his character; and it perhaps never happened (says that author) that the execution of his orders equalled the rapidity of his wishes. Though he disliked all public entertainments, yet when circumstances led him to any of them, he appeared to partake, and endeavoured to promote, the general pleasure. Sometimes he condescended even to dance and play at cards, though very rarely, and merely that he might not interrupt the etiquette of public manners, to which, when not in the field, he was very attentive. In the field he may be said to have spent the whole of his life from the period at which he first joined the army in the seven years war; for during the time that he was not engaged in actual warfare, and that time, taken altogether, did not exceed twelve years, he was always placed at the head of armies stationed on the frontier of some enemy's country. He was therefore a mere warrior, and as such had no fixed habitation. With respect to his table and lodging, he contented himself with whatever he found, requiring nothing but what absolute necessity demands, and what might be transported with ease from one place to another. His couch consisted of a heap of fresh hay sufficiently elevated, and scattered into considerable breadth, with a white sheet spread over it, with a cushion for his pillow, and with a cloak for his coverlid. He has been represented as dirty (c); but the representation is false. M. Anthing assures, that he was clean in his person, and that, when not on actual service, he washed himself frequently during the course of the day. It is among the singular, though unimportant circumstances of his life (says the same author), that, for the last twenty years, he had not made use of a looking-glass, or incumbered his person with either watch or money.

He was sincerely religious; took every opportunity of attending the offices of public devotion; and has been known, on Sundays and festivals, to deliver lectures on piety to those whom duty called to attend on him. We are told by an anonymous writer, in a miscellany not very forward to praise such men as Suworow, or indeed to praise piety in men of any description, that chancing one evening to overhear a captain abridge the prayer which his duty required him to repeat at the guard, the Field-marshal called out to him, "Thou unconscionable, abominable, impious man, thou wouldst cheat Heaven! Thou wouldst, no doubt, cheat likewise the Empress and me! I shall dismiss thee." His regard for sacred things is indeed very apparent in the elegant letter which, on the 1st of October 1795, he wrote to Charette, the hero of Vendee, whom he congratulates upon taking up arms to restore the temples of the God of his fathers. Alluding to this trait of his character, and to his detestation of Jacobinism under every form, a late writer in a most respectable miscellany has well characterized him as the Suworow.

> "Foe to religion's foe; of Russia's throne
> The prop, th' avenger, and the pride in one;
> Whose conquering arms, in bold defiance hurl'd,
> Crushed the rude monster of the western world."

We have already, when we thought not that we should so soon be called upon to write his life, observed, that he was a scholar, a man of science, and a poet. M. Anthing assures us, that from his earliest years he was enamoured of the sciences, and improved himself in them; but that as the military science was the sole object of his regard, those authors of every nation who investigate, illustrate, or improve it, engrossed his literary leisure. Hence Cornelius Nepos was with him a favourite classic; and he read, with great avidity and attention, the histories of Montecuculi and Turenne. Cæsar, however, and Charles XII. (says the same author) were the heroes whom he most admired, and whose activity and courage became the favourite objects of his imitation.

With respect to his moral character, we have every reason to believe that he was a man of the most incorruptible probity, immoveable in his purposes, and inviolable in his promises; that the cruelties of which he has been accused were the cruelties of Potemkin, and that by those who knew him he was considered as a man of unquestionable humanity. The love of his country, and the ambition to contend in arms for its glory, were the predominant passions of his active life; and to them, like the ancient Romans, he sacrificed every inferior sentiment, and consecrated, without reserve, all the powers of his body and mind. His military career was one long and uniform course of success and triumph, produced by his enterprising courage and extraordinary presence of mind; by his personal intrepidity and promptitude of execution; by the rapid and unparalleled movements of his armies; and by their perfect assurance of victory when fighting under his banners. Such was Alexander Basilovitch Count Suworow. In the year 1774 he married a daughter of the General Prince Iwan Prosorowski, by whom he had two children, now living: Natalia, married to General Count Nicolai Zubow; and Arcadius Count Suworow,

(c) By the anonymous author of the life of Catharine II.

a youth of great promise, who accompanied his father in his unparalleled march from Italy to Switzerland.

SWALLOW's-TAIL, in fortification, is a single tenaille, which is narrower towards the place than toward the country.

SWAN (See ANAS, *Encycl.*). It is now ascertained, beyond the possibility of doubt, that there are *black* swans, of equal size, and the same habitudes, with the common white swan of this island. These fowls have been seen chiefly in New Holland; and Captain Vancouver, when there, saw several of them in very stately attitudes, swimming on the water; and, when flying, discovering the under part of their wings and breasts to be white. Black swans were likewise seen in New Holland by Governor Philips, Captain White, and by a Dutch navigator, so long ago as in 1697. Governor Philips describes the black swan as a very noble bird, larger than the common swan, and equally beautiful in form. Mr White indeed says, that its size is not quite equal to that of the European swan; but both these authors agree with Captain Vancouver in mentioning some white feathers in its wings.

SWINTON (John), a very celebrated English antiquary, was a native of the county of Chester, the son of John Swinton of Bexton in that county, gent. He was born in 1703. The circumstances of his parents were probably not affluent, as he was entered at Oxford in the rank of a servitor at Wadham college. This was in October 1719. It may be presumed, that he recommended himself in that society by his talents and behaviour, as on June 30. 1723, he was elected a scholar on a Cheshire foundation in the college. In the December following, he took his first degree in arts. Before he became master of arts (which was on December 1. 1726), he had chosen the church for his profession, and was ordained deacon by the bishop of Oxford, May 30. 1725; and was afterwards admitted to priest's orders on May 28. 1727. He was not long without some preferment, being admitted to the rectory of St Peter le Bailey in Oxford (a living in the gift of the crown), under a sequestration, and instituted to it in February 1728. In June, the same year, he was elected a fellow of his college; but, desirous probably to take a wider view of the world, he accepted, not long after, the appointment of chaplain to the English factory at Leghorn, to which he had been chosen. In this situation he did not long enjoy his health; and leaving it on that account, he was at Florence in April 1733, where he attended Mr Coleman, the English envoy, in his last moments. Mr Swinton returned thro' Venice and Vienna; and, in company with some English gentlemen of fortune, visited Presburgh in Hungary, and was present at one of their assemblies.

Biog. Dictionary.

It is possible that he had not quitted England in the summer of 1730, for he was elected a Fellow of the Royal Society in June that year, and admitted about three months later. It was probably while he was abroad that he was admitted into some foreign societies; namely, the academy *degli Apatisti* at Florence, and the *Etruscan Academy* of Cortona. On his return, he seems to have taken up his abode at Oxford, where he resided all the latter part of his life, and was for many years chaplain to the gaol in that city. It may be presumed that he married in 1743; it was then, at least, that he gave up his fellowship. In 1759 he became bachelor of divinity: in 1767, he was elected *Custos Archivorum*, or keeper of the university records: and, on April 1. 1777, he died; leaving no children. His wife survived till 1784, and both were buried, with a very short and plain inscription, in the chapel of Wadham college.

It remains to take notice of the most important monuments of a literary man's life, his publications. These were numerous and learned, but not of great magnitude. He published, 1. "De Linguæ Etruriæ Regalis vernacula Dissertatio," 4to, 19 pages, Oxon, 1738. 2. "A critical essay concerning the words Δαίμων and Δαιμόνιον, occasioned by two late inquiries into the meaning of the demoniacs in the New Testament," 8vo, London, 1739. 3. "De priscis Romanorum literis dissertatio," 4to, 20 pages, Oxon. 1746. 4 "De Primogenio Etruscorum Alphabeto, dissertatio," Oxon, 1746. 5. "Inscriptiones Citieæ: sive in binas Inscriptiones Phœnicias, inter rudera Citii nuper repertas, conjecturæ. Accedit de nummis quibusdam Samaritanis et Phœnicius, vel insolitam præ se literaturam ferentibus, vel in lucem hactenus non editis, dissertatio," 4to, 87 pages, Oxon, 1750. 6 "Inscriptiones Citieæ: sive in binas alias Inscriptiones Phœnicias, inter rudera Citii nuper repertas, conjecturæ," 4to, 19 pages. 7. "De nummis quibusdam Samaritanis et Phœniciis, vel insolitam præ se literaturam ferentibus, vel in lucem hactenus non editis. dissertatio secunda," 4to, 36 pages 8. "Metilia: sive de quinario Gentis Metiliæ, e nummis vetustis cæteroquin minimum notæ, dissertatio," 4to, 22 pages. Oxon, 1750. 9. Several dissertations published in the Philosophical Transactions of the Royal Society. As, "A dissertation upon a Parthian Coin; with characters on the reverse resembling those of the Palmyrenes," vol. xlix. p. 593. "Some remarks on a Parthian Coin, with a Greek and Parthian legend, never before published," vol. l. p. 16. "A dissertation upon the Phœnician numeral characters anciently used at Sidon," vol. l. p. 791. "In nummum Parthicum hactenus ineditum conjectura," vol. li. p. 683. "A dissertation upon a Samnite Denarius, never before published," vol. lii. p. 28. "An account of a subærated Denarius of the Plætorian family, adorned with an Etruscan inscription on the reverse, never before published or explained," vol. lxii. p. 60. "Observations upon five ancient Persian Coins, struck in Palestine or Phœnicia before the dissolution of the Persian empire," vol. lxii. p. 345. Other papers by him may be found in the general index to the Philosophical Transactions. 10. A part of the Ancient Universal History, contained in the sixth and seventh volumes of that great work. The particulars of this piece of literary history were communicated by Dr Johnson to Mr Nichols, in a paper printed in the Gentleman's Magazine for December 1784, p. 892. The original of that paper, which affords a strong proof of the steady attachment of Johnson to the interests of literature, has been, according to his desire, deposited in the British Museum. The letter is as follows:

"To Mr Nichols.

"The late learned Mr Swinton of Oxford having one day remarked, that one man, meaning, I suppose, no man but himself, could assign all the parts of the Universal History to their proper authors, at the request of Sir Robert Chambers, or of myself, gave the account which I now transmit to you in his own hand,

being willing, that of so great a work the history should be known, and that each writer should receive his due proportion of praise from posterity. I recommend to you to preserve this scrap of literary intelligence, in Mr Swinton's own hand, or to deposite it in the Museum, that the veracity of the account may never be doubted.—I am, Sir, your most humble servant,

Dec. 6, 1784 SAM. JOHNSON."

The paper alluded to, besides specifying some parts written by other persons, assigns the following divisions of the history to Mr Swinton himself "The history of the Carthaginians, Numidians, Mauritanians, Gætulians, Garamantes, Melano Gætulians, Nigritæ, Cyrenaica, Marmarica, the Regio Syrtica, Turks, Tartars, and Moguls, Indians, and Chinese, a dissertation on the peopling of America, and one on the independency of the Arabs.

Swinton.

In the year 1740, Mr Swinton was involved in a law suit, in consequence of a letter he had published. It appears from a paper of the time *, that a letter from the Rev. Mr Swinton, highly reflecting on Mr George Baker, having fallen into the hands of the latter, the court of King's Bench made the rule absolute for an information against Mr Swinton. These two gentlemen were also engaged for some time in a controversy at Oxford; which took its rise from a matter relative to Dr Thistlethwaite, some time warden of Wadham, which then attracted much attention. Mr Swinton had the manners, and some of the peculiarities, often seen in very recluse scholars, which gave rise to many whimsical stories Among the rest, there is one mentioned by Mr Boswell, in the Life of Johnson, as having happened in the year 1754. Johnson was then on a visit in the university of Oxford. "About this time (he says) there had been an execution of two or three criminals at Oxford, on a Monday. Soon afterwards, one day at dinner, I was saying that Mr Swinton, the chaplain of the gaol, and also a frequent preacher before the university, a learned man, but often thoughtless and absent, preached the condemnation sermon on repentance, before the convicts, on the preceding day, Sunday; and that, in the close, he told his audience, that he should give them the remainder of what he had to say on the subject the next Lord's day. Upon which, one of our company, a doctor of divinity, and a plain matter-of-fact man, by way of offering an apology for Mr Swinton, gravely remarked, that he had probably preached the same sermon before the university. Yes, Sir (says Johnson); but the university were not to be hanged the next morning!"

* *The Champion, or Evening Advertiser*, June 17th 174-.

T.

Tacquet ‖ Talus.

TACQUET (Andrew), a Jesuit of Antwerp, who died in 1660. He was a most laborious and voluminous writer in mathematics. His works were collected, and printed at Antwerp, in one large volume in folio, 1669.

TALLOW-TREE. See CROTON (*Encycl.*), where, however, we have fallen into a mistake, which it is here our duty to correct. We learn from Sir George Staunton, that the candles made of the vegetable tallow are firmer than those made of animal tallow, and free from all offensive smell, contrary to what was rashly said in the article referred to. They are not, however, equal to those of wax or spermaceti; but the latter of these substances is not within the reach of the Chinese, and the art of blanching the former is little known to them. The tallow tree is said to have been transplanted to Carolina, and to flourish there as well as in China

TALOOK, an Arabic word, which signifies literally attachment, connection, dependence. In Bengal, however, where it occurs perpetually in the enumeration of the districts and subdivisions of that province contained in the institutes of Akber, it signifies a tenure of land. Hence the *talook* of Cathinat, the *talook* of Meheys the headman, the *talook* of Ahmed Khan, &c. See *A Dissertation concerning the Landed Property of Bengal*, by Sir Charles Rouse Boughton.

TALOOKDAR, the possessor of a talook.

TALOOKDARY, tenure of a talookdar.

TALUS, or TALUD, in architecture, the inclination or slope of a work; as of the outside of a wall, when its thickness is diminished by degrees, as it rises in height, to make it the firmer.

Talus ‖ Tanning.

TALUS, in fortification, means also the slope of a work, whether of earth or masonry.

TAMASCAL, the name given in California to a kind of sand-bath employed by the natives in the cure of the venereal disease. It is prepared by scooping a trench in the sand, two feet wide, one foot deep, and of a length proportioned to the size of the patient; a fire is then made through the whole extent of it, as well as upon the sand which was dug out of the hollow. When the whole is thoroughly heated, the fire is removed, and the sand stirred about, that the warmth may be equally diffused. The sick person is then stripped, laid down in the trench, and covered up to his chin with heated sand. In this position a very profuse sweat soon breaks out, which gradually diminishes according as the sand cools. The patient then rises and bathes in the sea, or the nearest river This process is repeated till a complete cure is obtained. While the patient is undergoing the operation of the tamascal, he drinks a considerable quantity of a warm sudorific, prepared by the decoction of certain herbs, chiefly of the shrub called by the Spaniards GOUVERNANTE, which see in this *Supplement*.

TAN is a substance found in most vegetables, which, not having hitherto been resolved into component parts, is therefore considered as simple. See *Vegetable and Animal Substances* in this *Suppl.*

TANNING is an art, of which a full account, according to the general practice in London and its vicinity, has been given under the proper title in the *Encyclopædia*. But since that article was written, the superior knowledge which has been obtained of the tan-

ning principle, as well as of the composition of the skins of animals (See *Vegetable and Animal Substances, Suppl.*), has suggested to scientific artists various methods of shortening the process by which leather is manufactured. Mr Seguin is said to have thrown much light upon the art of the tanner as it is practised in France; and in 1795 Mr William Desmond obtained a patent for practising Seguin's method in England. He obtains the tanning principle by digesting oak bark, or other proper material, in cold water, in an apparatus nearly similar to that used in the saltpetre works. That is to say, the water which has remained upon the powdered bark for a certain time, in one vessel, is drawn off by a cock, and poured upon fresh tan. This is again to be drawn off, and poured upon other fresh tan; and in this way the process is to be continued to the fifth vessel. The liquor is then highly coloured, and marks, as Mr Desmond says, from six to eight degrees on the hydrometer for salts. He calls this the tanning lixivium. The criterion to distinguish its presence is, that it precipitates glue from its aqueous solution, and is also useful to examine how far other vegetable substances, as well as oak bark, may be suitable to the purpose of tanning. The strong tanning liquor is to be kept by itself. It is found by trials with the glue, that the tanning principle of the first digester which receives the clear water, is, of course, first exhausted. But the same tan will still give a certain portion of the astringent principle, or gallic lixivium, to water. The presence of this principle is ascertained by its striking a black colour when added to a small quantity of the solution of vitriol of iron or green copperas. As soon as the water from the digester ceases to exhibit this sign, the tan is exhausted, and must be replaced with new. The gallic lixivium is reserved for the purpose of taking the hair off from hides.

Strong hides, after washing, cleaning, and fleshing, in the usual way, are to be immersed for two or three days in a mixture of gallic lixivium and one thousandth part by measure of dense vitriolic acid. By this means the hair is detached from the hides, so that it may be scraped off with a round knife. When swelling or raising is required, the hides are to be immersed for ten or twelve hours in another vat filled with water and one five-hundredth part of the same vitriolic acid. The hides being then repeatedly washed and dressed, are ready for tanning; for which purpose they are to be immersed for some hours in a weak tanning lixivium of only one or two degrees; to obtain which, the latter portions of the infusions are set apart; or else some of that which has been partly exhausted by use in tanning. The hides are then to be put into a stronger lixivium, where in a few days they will be brought to the same degree of saturation with the liquor in which they are immersed. The strength of the liquor will by this means be considerably diminished, and must therefore be renewed. When the hides are by this means completely saturated, that is to say, perfectly tanned, they are to be removed, and slowly dried in the shade.

Calf skins, goat skins, and the like, are to be steeped in lime-water after the usual fleshing and washing. These are to remain in the lime water, which contains more lime than it can dissolve, and requires to be stirred several times a day. After two or three days, the skins are to be removed, and perfectly cleared of their lime by washing and pressing in water. The tanning process is then to be accomplished in the same manner as for the strong hides, but the lixivium must be considerably weaker. Mr Desmond remarks, that lime is used instead of the gallic lixivium for such hides as are required to have a close grain; because the acid mixed with that lixivium always swells the skins more or less; but that it cannot with the same convenience be used with thick skins, on account of the considerable labour required to clear them of the lime; any part of which, if left, would render them harsh and liable to crack. He recommends, likewise, as the best method to bring the whole surface of the hides in contact with the lixivium, that they should be suspended vertically in the fluid by means of transverse rods or bars, at such a distance as not to touch each other. By this practice much of the labour of turning and handling may be saved.

Mr Desmond concludes his specification, by observing, that in some cases it will be expedient to mix fresh tan with the lixivium; and that various modifications of strength, and other circumstances, will present themselves to the operator. He affirms that, in addition to the great saving of time and labour in this method, the leather, being more completely tanned, will weigh heavier, wear better, and be less susceptible of moisture than leather tanned in the usual way; that cords, ropes, and cables, made of hemp or speartery, impregnated with the tanning principle, will support much greater weights without breaking, be less liable to be worn out by friction, and will run more smoothly on pulleys; insomuch that, in his opinion, it will render the use of tar in may cases, particularly in the rigging of ships, unnecessary; and, lastly, that it may be substituted for the preservation of animal food instead of salt.

Mr Nicholson, from whose Philosophical Journal we have taken this account of Mr Desmond's method of tanning, made some very proper enquiries at one of the first manufacturing houses in the borough of Southwark, concerning its value. He was told by one of the partners, that the principle upon which the new process is founded had been long known to them; but that they preferred the old and slower method, because the hides are found to feed and improve in their quality by remaining in the pit. He could gain no satisfactory information of what is meant by this feeding and improving; and; without taking upon us to decide between the advantages peculiar to Desmond's method and those of the common practice, we cannot help saying that this objection of the tanner at Southwark appears to us to be that of a man who either understands not the principles of his own art, or has some reason for opposing the progress of improvement, if it do not originate in his own house.

TASSIE (James) modeller, whose history is intimately connected with a branch of the fine arts in Britain, was born in the neighbourhood of Glasgow of obscure parents; and began his life as a country stone mason, without the expectation of ever rising higher. Going to Glasgow on a fair day, to enjoy himself with his companions, at the time when the Foulis's were attempting to establish an academy for the fine arts in that city, he saw their collection of paintings and felt an irresistible impulse to become a painter. He removed to Glasgow; and in the academy acquired a knowledge of drawing, which unfolded and

improved his natural taste He was frugal, industrious, and persevering; but he was poor, and was under the necessity of devoting himself to stone-cutting for his support: not without the hopes that he might one day be a statuary if he could not be a painter. Resorting to Dublin for employment, he became known to Dr Quin, who was amusing himself in his leisure hours with endeavouring to imitate the precious stones in coloured pastes, and take accurate impressions of the engravings that were on them.

That art was known to the ancients; and many specimens from them are now in the cabinets of the curious. It seems to have been lost in the middle ages; was revived in Italy under Leo X. and the Medici family at Florence; became more perfect in France under the regency of the Duke of Orleans, by his labours and those of Homberg. By those whom they instructed as assistants in the laboratory it continued to be practised in Paris, and was carried to Rome. Their art was kept a secret, and their collections were small. It is owing to Quin and to Tassie that it has been carried to such high perfection in Britain, and attracted the attention of Europe.

Dr Quin, in looking out for an assistant, soon discovered Tassie to be one in whom he could place perfect confidence. He was endowed with fine taste: he was modest and unassuming: he was patient; and possessed the highest integrity. The Doctor committed his laboratory and experiments to his care. The associates were fully successful; and found themselves able to imitate all the gems, and take accurate impressions of the engravings.

As the Doctor had followed the subject only for his amusement, when the discovery was completed, he encouraged Mr Tassie to repair to London, and to devote himself to the preparation and sale of those pastes as his profession.

In 1766 he arrived in the Capital. But he was diffident and modest to excess; very unfit to introduce himself to the attention of persons of rank and of affluence: besides, the number of engraved gems in Britain was small; and those few were little noticed. He long struggled under difficulties which would have discouraged any one who was not possessed of the greatest patience, and the warmest attachment to the subject. He gradually emerged from obscurity, obtained competence; and what to him was much more, he was able to increase his collection, and add higher degrees of perfection to his art. His name soon became respected, and the first cabinets in Europe were open for his use; and he uniformly preserved the greatest attention to the exactness of the imitation and accuracy of the engraving, so that many of his pastes were sold on the Continent by the fraudulent for real gems. His fine taste led him to be peculiarly careful of the impression; and he uniformly destroyed those with which he was in the least dissatisfied. The art has been practised of late by others; and many thousands of pastes have been sold as Tassie's, which he would have considered as injurious to his fame. Of the fame of others he was not envious; for he uniformly spake with frankness in praise of those who executed them well, though they were endeavouring to rival himself.

To the ancient engravings he added a numerous collection of the most eminent modern ones; many of which approach in excellence of workmanship, if not in simplicity of design and chastity of expression, to the most celebrated of the ancient. Many years before he died he executed a commission for the late Empress of Russia, consisting of about 15,000 different engravings (See GEM, *Encycl.*). At his death, in 1799, they amounted to near 20,000; a collection of engravings unequalled in the world. Every lover of the fine arts must be sensible of the advantage of it for improvement in knowledge and in taste. The collection of Feloix at Paris consisted of 1800 articles; and that of Dehn at Rome of 2500.

For a number of years, Mr Tassie practised the modelling of portraits in wax, which he afterwards moulded and cast in paste. By this, the exact likeness of many eminent men of the present age will be transmitted to posterity as accurately as those of the philosophers and great men have been by the ancient statuaries. In taking likenesses he was, in general, uncommonly happy; and it is remarkable, that he believed there was a certain kind of inspiration (like that mentioned by the poets) necessary to give him full success. The writer of this article, in conversing with him repeatedly on the subject, always found him fully persuaded of it. He mentioned many instances in which he had been directed by it; and even some, in which, after he had laboured in vain to realize his ideas on the wax, he had been able, by a sudden flash of imagination, to please himself in the likeness several days after he had last seen the original.

He possessed also an uncommonly fine taste in architecture, and would have been eminent in that branch if he had followed it.

In private life Mr Tassie was universally esteemed for his uniform piety, and for the simplicity, the modesty, and benevolence, that shone in the whole of his character.

TASTELESS EARTH (*agust erde*), the name given by Professor Trommsdorff to a new simple earth, which he discovered in the Saxon beryl. It is distinguished (he says) from other earths by the following properties: It is white, and totally insoluble in water. In a fresh state, when moistened with water, it is somewhat ductile. In the fire it becomes transparent and very hard, so as to scratch glass, but remains insipid and insoluble in water. The burnt earth dissolves very easily in acids, and produces with them peculiar salts, which are entirely devoid of taste; and hence he gave it the name of *tasteless earth*. Fixed alkalies do not dissolve this earth either in the dry or in the wet way; and it is equally insoluble with the carbonic acid and with caustic ammonia. It has a greater affinity to the oxalic than to other acids. Professor Trommsdorff informs us, that a full account of this earth, accompanied with an accurate description, by Dr Bernhardi, of the fossil in which it is found, will appear in the first part of the eight volume of his *Journal of Pharmacy*.

TEETH, of various sorts of machines, as of mill wheels, &c. These are often called cogs by the workmen; and by working in the pinions, rounds, or trundles, the wheels are made to turn one another. Mr Emerson (in his Mechanics, prop. 25.) treats of the theory of teeth, and shews that they ought to have the figure of epicycloids, for properly working in one another.

TEKAWY, in Bengal, money advanced by government

Telescope, Temperament of the Scale of Music.

ment to the proprietors or cultivators of land to aſſiſt them under circumſtances of diſtreſs.

TELESCOPE, is an inſtrument which has been ſo completely deſcribed in the *Encyclopædia*, that it is introduced into this place merely to notice an ingenious ſuggeſtion of Mr Nicholſon's for improving the achromatic teleſcope, by adding an artificial iris to the object glaſs. Suppoſe (ſays he) a braſs ring to ſurround the object end of the teleſcope, and upon this let eight or more triangular ſlips of braſs be fixed, ſo as to revolve on equi-diſtant pins paſſing through each triangle near one of its corners. If the triangles be ſlided inwards upon each other, it may readily be apprehended that they will cloſe the aperture; and if they be all made to revolve or ſlide backwards alike, it is clear that their edges will leave an octagonal aperture, greater or leſs according to circumſtances. The equable motion of all the triangles may be produced either by pinions and one concave toothed wheel, or by what is called ſnail-work. Another kind of iris, more compact, may be made, by cauſing thin elaſtic ſlips of braſs to ſlide along parallel to the tube, and be conducted each through a ſlit in a braſs cap which ſhall lead them acroſs the aperture in a radial direction. It is probable alſo that the artiſt, who ſhall carry theſe hints into effect, may alſo think of ſeveral other methods.

This thought occurred to the author, from contemplating the contraction and dilatation of the iris of the eye, according as we look at an object more or leſs luminous. Theſe variations are ſo great, that in the obſervable variations of the human eye, the aperture is thirty times as large at one time as at another, whilſt in the cat the proportion is greater than a hundred to one.

TEMPERAMENT OF THE SCALE OF MUSIC.

1 Introduction.

When the conſiderate reader reflects on the large and almoſt numberleſs diſſertations on this ſubject, by the moſt eminent philoſophers, mathematicians, and artiſts, both of ancient and modern times, and the important points which divided, and ſtill divide, their opinions, he will not ſurely expect, in a Work like our's, the deciſion of a queſtion which has hitherto eluded their reſearches. He will rather be diſpoſed, perhaps, to wonder how a ſubject of this nature ever acquired ſuch importance in the minds of perſons of acknowledged talents (for ſurely no perſon will refuſe this claim to Pythagoras, to Ariſtotle, Euclid, Ptolemy, Galileo, Wallis, Euler, and many others, who have written elaborate treatiſes on the ſubject); and his ſurpriſe will increaſe, when he knows that the treatiſes on the ſcale of muſic are as numerous and voluminous in China, without any appearance of their being borrowed from the ingenious and ſpeculative Greeks.

The ingenious, in all cultivated nations, have remarked the great influence of muſic; and they found no difficulty in perſuading the nations that it was a gift of the gods. Apollo and his ſacred choir are perhaps the moſt reſpectable inhabitants of the mythological heavens of the Greeks. Therefore all nations have conſidered muſic as a proper part of their religious worſhip. We doubt not but that they found it fit for exciting or ſupporting thoſe emotions and ſentiments which were ſuited to adoration, thanks, or petition. Nor would the Greeks have admitted muſic into their ſerious dramas, if they had not perceived that it heightened the effect. The ſame experience made them employ it as an aid to military enthuſiaſm; and it is recorded as one of the reſpectable accompliſhments of Epaminondas, that he had the muſical inſtructions of the firſt maſters, and was eminent as a performer.

Thus was the ſtudy of muſic ennobled, and recommended to the attention of the greateſt philoſophers. Its cultivation was held an object of national concern, and its profeſſors were not allowed to corrupt it in order to gratify the faſtidious taſte of the luxurious or the ſenſualiſt, who ſought from it nothing but amuſement. But its influence was not confined to theſe public purpoſes; and, while the men of ſpeculation found in muſic an inexhauſtible fund of employment for their genius and penetration, and their poets felt its aid in their compoſitions, it was hailed by perſons of all ranks as the ſoother of the cares and anxieties, and ſweetener of the labours of life. *O Phœbi decus!—laborum dulce lenimen.* Poor Ovid, the victim of what remained of good in the cold heart of Octavius, found its balm.

Exul eram (ſays he): *requieſque mihi, non fama petita eſt*
Mens intenta ſuis ne foret uſque malis.
Hoc eſt cur cantet vinctus quoque compede foſſor,
Indocili numero cum grave molit opus.
Cantet et innitens limoſæ pronus arenæ
Adverſo tardam qui trahit amne ratem,
Quique ferens pariter lentos ad pectora remos,
In numerum pulsâ brachia verſat aquâ.
Feſſus ut incubuit baculo, ſaxove reſedit
Paſtor; arundineo carmine mulcet oves.
Cantantis pariter, pariter data penſa trahentis
Fallitur ancillæ, decipiturque labor.

2 Scale of muſic. It requires temperament.

It is chiefly in this humble department of muſical influence that we propoſe at preſent to lend our aid. What has been ſaid in the article Music, *Encycl.* is ſufficient for informing the reader of what is received as the ſcale of muſic, and the inequality of its different ſteps, the tones major and minor, ſemitone, comma, &c. We ſhall only obſerve, that what is there delivered on temperament by M. d'Alembert, after Rameau, bears the evident mark of uncertainty or want of confidence in the principle adopted as the rule of temperament; and we have learned, ſince the printing of that article, that the inſtructions there delivered have not that perſpicuity and preciſion that are neceſſary for enabling a perſon to execute the temperament recommended by Rameau; that is, to tune a keyed inſtrument with certainty, according to that ſyſtem or conſtruction of the ſcale.

If ſuch be the caſe, we are in ſome meaſure diſappointed; becauſe we ſelected that treatiſe of D'Alembert as the performance of a man of great eminence as a mathematician and philoſopher, aiming at public inſtruction more than his own fame, by this elementary abſtract of the great work of the moſt eminent muſician in France.

Few can tune a harpſichord;

To be able to tune a harpſichord with certainty and accuracy, ſeems an indiſpenſable qualification of any perſon worthy of the name of a *muſician*. It would certainly be thought an unpardonable deficiency in a violin performer if he could not tune his inſtrument; yet we are well informed, that many profeſſional performers on the harpſichord cannot do it, or cannot do it any other way than by uncertain and painful trial, and, as it were, groping

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groping in the dark; and that the tuning of harpsichords and organs is committed entirely to tuners by profession. This is a great inconvenience to persons residing in the country; and therefore many take lessons from the professed harpsichord tuners, who also profess to teach this art. We have been present during some of these lessons; but it did not appear to us that the instructions were such as could enable the scholar to tune an instrument when alone, unless the lessons had been so frequent as to form the ear to an instantaneous judgment of tune by the same habit that had instructed the teacher. There seemed to be little principle that could be treasured up and recollected when wanted.

3 Yet Nature furnishes abundant means of doing this.

Yet we cannot help thinking that there are phenomena or facts in music, sufficiently precise to furnish principles of absolute certainty for enabling us to produce temperaments of the scale which shall have determined characters, and among which we may choose such a one as shall be preferable to the others, according to the purposes we have in view; and we think that these principles are of such easy application, that any person, of a moderate sensibility to just intonation, may, without much knowledge or practice in music, tune his harpsichord with all desirable accuracy. We propose to lay these before the reader. We might content ourselves with simply giving the practical rules deduced from the principles; but it is surely more desirable to perceive the validity of the principles. This will give us confidence in the deduced rules of practice. In the employment of sacred music, an inspired writer counsels us to sing, not only "with the heart, but with the understanding also." We may, without irreverence, recommend the same thing here. Let us therefore attend a little to the dictate of untutored Nature, and see how she teaches all mankind to form the scale of melody.

All nations sing by one scale.

It is a most remarkable fact, that, in all nations, however they may differ in the structure of that chaunt which we call the accent, or tone, or twang, in the colloquial language of a particular nation, or in the favourite phrases or passages which are most frequent in their songs, all men make use of the same rises and falls, or inflexions of voice, in their musical language or airs. We have heard the songs of the Iroquois, the Cherokee, and the Esquimaux, of the Carib, and the inhabitant of Paraguay; of the African of Negroland and of the Cape, and of the Hindoo, the Malay, and the native of Otaheite—and we found none that made use of a different scale from our own, although several seemed to be very sorry performers by any scale. There must be some natural foundation for this uniformity. We may never discover this; but we may be fortunate enough to discover facts in the phenomena of sound which invariably accompany certain modifications of musical sentiment. If we succeed, we are intitled to suppose that such inseparable companions are naturally connected; and to conclude, that if we can insure the appearance of those facts in sound, we shall also give occasion to those musical sentiments or impressions.

5 Musical pitch, what?

There is a quality in lengthened or continued sound which we call its pitch or note, by which it may be accounted shrill or hoarse. It may be very hoarse in the beginning, and during its continuance it may grow more and more shrill by imperceptible gradations. In this case we are sensible of a kind of progress from the one state of sound to the other. Thus, while we gently draw the bow across the string of a bass viol, if we at the same time slide the finger slowly along the string, from the nut toward the bridge, the sound, from being hoarse, becomes gradually acute or shrill. Hoarse and shrill therefore are not different qualities, although they have different names, but are different states or degrees of the same quality, like cold and heat, near and far, early and late, or, what is common to all these, little and great. A certain state of the air is accounted neither hot nor cold. All states on one side of this are called warm, or hot; and all on the other are cold. In like manner, a certain sound is the boundary between those that are called hoarse and those called shrill. The chemist is accustomed to say, that the temperature of a body is higher when it is warmer, and lower when colder. In like manner, we are accustomed to say, that a person raises or depresses the pitch of his voice when it becomes more shrill or more hoarse. The ancient Greeks, however, called the shriller sounds *low*, and the hoarser sounds *high*; probably because the hoarser sounds are generally stronger or louder, which we are also accustomed to consider as higher. In common language, a low pitch of voice means a faint sound, but in musical language it means a hoarser sound. The sound that is neither hoarse nor shrill is some ordinary pitch of voice, but without any precise criterion.

The change observed in the pitch of a violin string, when the finger is carried along the finger-board with a continued motion, is also continuous; that is, not by starts: we call it gradual, for want of a better term, although gradual properly means *gradatim*, by degrees, steps, or starts, which are not to be distinguished in this experiment. But we may make the experiment in another way. After sounding the open string, and while the bow is yet moving across it, we may put down the finger about $1\frac{2}{3}$ inches from the nut. This will change the sound into one which is *sensibly* shriller than the former, and there is a manifest start from the one to the other. Or we may put down the finger $2\frac{1}{2}$ inches from the nut; the sound of the open string will change to a shriller sound, and we are sensible that this change or step is greater than the former. Moreover, we may, while drawing the bow across the string, put down one finger at $1\frac{2}{3}$ inches, and, immediately after, put down another finger at $2\frac{1}{2}$ inches from the nut. We shall have three sounds in succession, each more shrill than the preceding, with two manifest steps, or subsultory changes of pitch.

Now since the last sound is the same as if the second had not been sounded, we must conceive the sum of the two successive changes as equivalent, or equal to the change from the first to the third. This change seems somehow to include the other two, and to be made up of them, as a whole is made up of its parts, or as $2\frac{1}{2}$ inches are made up of $1\frac{2}{3}$ and $\frac{5}{6}$ of an inch, or as the sum 15 is made up of 10 and 5.

8 We have a notion of something like an interval between the notes of music.

Thus it happens that thinking persons conceive something like or analogous to a distance, or interval, between these sounds. It is plain, however, that there can be no real distance or space interposed between them; and it is not easy to acquire a distinct notion of the bulk or magnitude of these intervals. This conception is purely figurative and analogical; but the analogy is very good, and the observation of it, or conjecture

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jecture about it, has been of great ſervice in the ſcience of muſic, by making us ſearch for ſome preciſe meaſure of thoſe manifeſt intervals of muſical ſounds.

9. It muſt now be remarked, that it is in this reſpect alone that ſounds are ſuſceptible of muſic. Nor are all ſounds poſſeſſed of this quality. The ſmack of a whip, the exploſion of a muſket, the ruſhing of water or wind, the ſcream of ſome animals, and many other ſounds, both momentary and continuous, are mere noiſes; and can neither be called hoarſe nor ſhrill. But, on the other hand, many ſounds, which differ in a thouſand circumſtances of loudneſs, ſmoothneſs, mellowneſs, &c. which make them pleaſant or diſagreeable, have this quality of muſical pitch, and may thus be compared. The voice of a man or woman, the ſound of a pipe, a bell, a ſtring, the voice of an animal, nay, the ſingle blow on an empty caſk—may all have one pitch, or we may be ſenſible of the interval between them. We can, in all caſes, tighten or ſlacken the ſtring of a violin, till the moſt uninformed hearer can pronounce with certainty that the pitch is the ſame. We are indebted to the celebrated Galileo for the diſcovery of that phyſical circumſtance in all thoſe ſounds which communicates this remarkable quality to them, and even enables us to induce it on any noiſe whatever, and to determine, with the utmoſt preciſion, the muſical pitch of the ſound, and the interval between any two ſuch ſounds. Of this we ſhall ſpeak fully hereafter; and at preſent we only obſerve, that two ſounds, having the ſame pitch, are called UNISONS by muſicians, or are ſaid to be in *uniſon* to one another.

When two untaught men attempt to ſing the ſame air together, they always ſing in uniſon, unleſs they expreſsly mean to ſing in different pitches of voice. Nay, it is an extremely difficult thing to do otherwiſe, except in a few very peculiar caſes. Alſo, when a man and woman, wholly uninſtructed in muſic, attempt to ſing the ſame air, they alſo *mean* to ſing the ſame muſical notes through the whole air; and they generally imagine that they do ſo. But there is a manifeſt difference in the ſounds which they utter, and the woman is ſaid to ſing more SHRILL, and the man more HOARSE. A very plain experiment, however, will convince them that they are miſtaken. *N. B.* We are now ſuppoſing that the performers have ſo much of a muſical ear, and flexible voice, as to be able to ſing a common ballad, or a pſalm tune, with tolerable exactneſs, and that they can prolong or dwell upon any particular note when deſired.

Let them ſing the common pſalm tune called St David's, in the ſame way that they practiſe at church; and when they have done it two or three times, in order to fix their voices in tune, and to feel the general impreſſion of the tune, let the woman hold on in the firſt note of the tune, which we ſuppoſe to be *g*, while the man ſings the firſt three in ſucceſſion, namely *g*, *d*, *g*. He will now perceive, that the laſt note ſung by himſelf is the ſame with that ſung by the woman, and which ſhe thinks that ſhe is ſtill holding on in the firſt note of the tune. Let this be repeated till the performance becomes eaſy. They will then perceive the perfect ſameneſs, in reſpect of muſical pitch, of the woman's firſt note of this tune and the man's third note. Some difference, however, will ſtill be perceived; but it will not be in the pitch, but in the ſmoothneſs, or clearneſs, or other agreeable quality of the woman's note.

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When this is plainly perceived, let the man try by what continued ſteps he muſt raiſe his pitch, in order to arrive at the woman's note from his own. If he is accuſtomed to common ballad ſinging, he will have no great difficulty in doing this; and will find that, beginning with his own note, and ſinging gradually up, his eighth note will be the woman's note. In ſhort, if two flutes be taken, one of which is twice as long as the other, and if the man ſing in uniſon with the large flute, the woman, while ſinging, as ſhe thinks, the ſame notes with the man, will be found to be ſinging in uniſon with the ſmaller flute.

In ſteps of a ſcale, eight notes.

This is a remarkable and moſt important fact in the phenomena of muſic. This interval, comprehending and made up of ſeven ſmaller intervals, and requiring eight ſounds to mark its ſteps, is therefore called an OCTAVE. Now, ſince the female performer follows the ſame dictates of natural ear in ſinging her tune that the man follows in ſinging his, and all hearers are ſenſible that they are ſinging the ſame tune, it neceſſarily follows, that the two ſerieſes of notes are perfectly ſimilar, though not the ſame: For there muſt be the ſame interval of an octave between any ſtep of the lower octave and the ſame ſtep of the upper one. In whatever way, therefore, we conceive one of theſe octaves to be parcelled out by the different ſteps, the partition of both muſt be ſimilar. If we repreſent both by lines, theſe lines muſt be ſimilarly divided. Each partial interval of the one muſt bear the ſame relation to the whole, or to any other interval, as its ſimilar interval in the other octave bears to the whole of that octave, or to the other correſponding interval in it.

11 Octave.

12 All octaves are ſimilar.

Farther, we muſt now obſerve, that although this ſimilarity of the octaves was firſt obſerved or diſcovered by means of the ordinary voices of man and woman, and is a legitimate inference from the perfect ſatisfaction that each feels in ſinging what they think the ſame notes, this is not the only foundation or proof of the ſimilarity. Having acquired the knowledge of that phyſical circumſtance, on which the pitch of muſical ſounds depends, we can demonſtrate, with all the rigour of geometry, that the ſeveral notes in the man and woman's octave *muſt* have the ſame relation to their reſpective commencements, and that theſe two great intervals are ſimilarly divided. But farther ſtill, we can demonſtrate that this ſimilarity is not confined to theſe two octaves. This may even be proved, to a certain extent, by the ſame original experiment. Many men can ſing two octaves in ſucceſſion, and there are ſome rare examples of perſons who can ſing three. This is more common in the female voice. This being the caſe, it is plain that there will be two octaves common to both voices; and therefore four octaves in ſucceſſion, all ſimilar to each other. The ſame ſimilarity may be obſerved in the ſounds of inſtruments which differ only by an octave. And thus we demonſtrate that all octaves are ſimilar to each other. This ſimilarity does not conſiſt merely in the ſimilarity of its diviſion. The ſound of a note and its octave are ſo like each other, that if the ſtrength or loudneſs be properly adjuſted, and there be no difference in kind, or other circumſtances of clearneſs, ſmoothneſs, &c. the two notes, when ſounded together, are indiſtinguiſhable, and appear only like a more brilliant note. They coaleſce into one ſound. Nay, moſt clear mellow notes, ſuch as thoſe of a fine human

 voice,

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voice, really contain each two notes, one of which is octave to the other.

We ſaid that this reſemblance of octaves is an important fact in the ſcience of muſic. We now ſee why it is ſo. The whole ſcale of muſic is contained in one octave, and all the reſt are only repetitions of this ſcale. And thus is the doctrine of the ſcale of melody brought within a very moderate compaſs, and the problem is reduced to that of the repartition of a ſingle octave, and ſome attention to the junction with the ſimilar ſcales of the adjoining octaves. This partition is now to be the ſubject of diſcuſſion.

14
All muſic contained in the octave; hence called DIAPASON.

15
Melodies, or tunes, or airs, were the firſt muſic.

In the infancy of ſociety and cultivation, it is probable that the melodies or tunes, which delighted the ſimple inhabitants, were equally ſimple. Being the ſpontaneous effuſions of individuals, perhaps only occaſional, and never repeated. they would periſh as faſt as produced. The airs were probably connected with ſome of the rude rhimes, or gingles of words, which were bandied about at their feſtivals; or they were aſſociated with dancing. In all theſe caſes they muſt have been very ſhort, conſiſting of a few favourite paſſages or muſical phraſes. This is the caſe with the common airs of all ſimple people to this day. They ſeldom extend beyond a ſhort ſtanza of poetry, or a ſhort movement of dancing. The artiſt who could compoſe and keep in mind a piece of conſiderable length, muſt have been a great rarity, and a minſtrel fit for the entertainment of princes; and therefore much admired, and highly rewarded: his excellencies were almoſt incommunicable, and could not be preſerved in any other way but by repeated performance to an attentive hearer, who muſt alſo be an artiſt, and muſt patiently liſten, and try to imitate; or, in ſhort, to get the tune by heart. It muſt have been a long time before any diſtinct notion was formed of the relation of the notes to each other. It was perhaps impoſſible to recollect today the preciſe notes of yeſterday. There was nothing in which they were fixed till inſtrumental muſic was invented. This has been found in all nations; but it appears that long continued cultivation is neceſſary for raiſing this from a very ſimple and imperfect ſtate. The moſt refined inſtrument of the Greek muſicians was very far below our very ordinary inſtruments. And, till ſome method of notation was invented, we can ſcarcely conceive how any determined partition of the octave could be made generally known.

16
KEY-NOTE or FUNDAMENTAL.

Accordingly, we find that it was not till after a long while, and by very rude and awkward ſteps, that the Greeks perceived that the whole of muſic was compriſed in the octave. The firſt improved lyre had but four ſtrings, and was therefore called a TETRACHORD; and the firſt flutes had but three holes, and four notes; and when more were added to the ſcale, it was done by joining two lyres and two flutes together. Even this is an inſtructive ſtep in the hiſtory of muſical ſcience: For the four ſounds of the inſtrument have a natural ſyſtem, and the awkward and groping attempts to extend the muſic, by joining two inſtruments, the ſcale of the one following, or being a continuation of that of the other, pointed out the DIAPASON or *totality* of the octave, and the relation of the whole to a principal ſound, which we now call the *fundamental* or *key*, it being the loweſt note of our ſcale, and the one to which the other notes bear a continual reference. It would far exceed the limits of this Work to narrate the ſucceſſive changes and additions made by the Greeks in their lyre; yet would this be a very ſure way of learning the natural formation of our muſical ſcale. We muſt refer our readers to Dr Wallis's Appendix to his edition of the Commentary of Porphyrius in Ptolemy's Harmonics, as by far the moſt perſpicuous account that is extant of the Greek muſic. We ſhall pick out from among their different attempts ſuch plain obſervations as will be obvious to the feelings of any perſon who can ſing a common tune.

17
The octave is naturally divided into two TETRACHORDS.

Let ſuch a perſon firſt ſing over ſome plain and cheerful, or at leaſt not mournful, tune, ſeveral times, ſo as to retain a laſting impreſſion of the chief note of the tune, which is generally the laſt. Then let him begin, on the ſame note, to ſing in ſucceſſion the riſing ſteps of the ſcale, pronouncing the ſyllables *do, re, mi, fa, ſol, la, ſi, do*. He will perhaps obſerve, that this chaunt naturally divides itſelf into two parts or phraſes, as the muſicians term it. If he does not, of himſelf, make this remark, let him ſing it, however, in that manner, pauſing a little after the note *fa*. Thus, *do, re, mi, fa; ſol, la, ſi, do.—Do, re, mi, fa; ſol, la, ſi, do.*

Having done this ſeveral times, and then repeated it without a pauſe, he will become very ſenſible of the propriety of the pauſe, and of this natural diviſion of the octave. He will even obſerve a conſiderable ſimilarity between theſe two muſical phraſes, without being able, at firſt, to ſay in what it conſiſts.

18
The ſteps of the ſcale are unequal, and the two tetrachords are ſimilar.

Let him now ſtudy each phraſe apart, and try to compare the magnitude of the changes of ſound; or ſteps which he makes in riſing from *do* to *re*, from *re* to *mi*, and from *mi* to *fa*. We apprehend that he will have no difficulty in perceiving, after a few trials, that the ſteps *do re*, and *re mi*, are ſenſibly greater than the ſtep *mi fa*. We feel the laſt ſtep as a ſort of ſlide; as an attempt to make as little change of pitch as we can. Once this is perceived, it will never be forgotten. This will be ſtill more clearly perceived, if, inſtead of theſe ſyllables, he uſe only the vowel *a*, pronounced as in the word *ball*, and if he ſing the ſteps, ſliding or ſlurring from the one to the other. Taking this method, he cannot fail to notice the ſmallneſs of the third ſtep.

19
Let the ſinger farther conſider, whether he does not feel this phraſe muſical or agreeable, making a ſort of tune or chaunt, and ending or cloſing agreeably after this ſlide of a ſmall, or, as it were, half ſtep. It is generally thought ſo; and is therefore called a CLOSE, a CADENCE, when we end with a half ſtep aſcending.

20
Let the ſinger now reſume the whole ſcale, ſinging the four laſt notes *ſol, la, ſi, do,* louder than the other four, and calling off his attention from the low phraſe, and fixing it on the upper one. He will now be able to perceive that this, like the other, has two conſiderable ſteps; namely, *ſol la* and *la ſi*, and then a ſmaller ſtep, *ſi do*. A few repetitions will make this clear, and he will then be ſenſible of the nature of the ſimilarity between theſe two phraſes, and the propriety of this great diviſion of the ſcale into the intervals *do, fa*, and *ſol, do*, with an interval *fa, ſol* between them.

This was the foundation of the tetrachords, or lyres of four ſtrings, of the Greeks. Their earlieſt muſic or modulation ſeems to have extended no farther than this phraſe. It pleaſed them, as a ring of four bells pleaſes many country pariſhes.

21
CLOSE or CADENCE.

The ſinger will perceive the ſame ſatisfaction with the cloſe of this ſecond phraſe as with that of the former: and if he now ſing them both, in immediate ſucceſſion,

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ſucceſſion, with a ſlight pauſe between, we imagine that he will think the cloſe or cadence on the upper *do* even more ſatisfactory than that on the *fa*. It ſeems to us to complete a tune. And this impreſſion will be greatly heightened, if another perſon, or an inſtrument, ſhould ſound the lower *do*, while he cloſes on the upper *do* its octave. *Do* ſeems to be expected, or looked for, or ſought after. We take *ſi* as a ſtep to *do*, and there we reſt.

22
The third and ſeventh ſtep are the ſmalleſt.

Thus does the octave appear to be naturally compoſed of ſeven ſteps, of which the firſt, ſecond, fourth, fifth, and ſixth, are more conſiderable, and the third and ſeventh very ſenſibly ſmaller. Having no direct meaſures of their quantity, nor even a very diſtinct notion of what we mean by their quantity, magnitude, or bulk, we cannot pronounce, with any certainty, whether the greater ſteps are equal or unequal; and we preſume them to be equal. Nor have we any diſtinct notion of the proportion between the larger and ſmaller ſteps. In a looſe way we call them half notes, or ſuppoſe the riſe from *mi* to *fa*, or from *ſi* to *do*, to be one-half of that from *do* to *re*, or from *re* to *mi*.

23
The Pythagorean diſcoveries did not improve the Greek muſic.

Accordingly, this ſeems to have been all the muſical ſcience attained by the Greek artiſts, or thoſe who did not profeſs to ſpeak philoſophically on the ſubject. And even after Pythagoras publiſhed the diſcovery which he had made, or more probably had picked up among the Chaldeans or Egyptians, by which it appeared, that accurate meaſures of ſounds, in reſpect to gravity and acuteneſs, were attainable, it was affirmed by Ariſtoxenus, a ſcholar of Ariſtotle, and other eminent philoſophers, that theſe meaſures were altogether artificial, had no connection with muſic, and that the ear alone was the judge of muſical intervals. The artiſt had no other guide in tuning his inſtrument; becauſe the ratios, which were ſaid to be inherent in the ſounds (though no perſon could ſay how), were never perceived by the ear. The juſtice of this opinion is abundantly confirmed by the awkward attempt of the Greeks to improve the lyre by means of theſe boaſted ratios. Inſtead of illuſtrating the ſubject, they ſeem rather to have brought an additional obſcurity upon it, and threw it into ſuch confuſion, that although many voluminous diſſertations were written on it, and on the compoſition of their muſical ſcale, the account is ſo perplexed and confuſed, that the firſt mathematicians and artiſts of Europe acknowledge, that the whole is an impenetrable myſtery. Had the philoſophers never meddled with it, had they allowed the practical muſicians to conſtruct and tune their inſtruments in their own way, ſo as to pleaſe their ear, it is ſcarcely poſſible that they ſhould not have hit on what they wanted, without all the embarraſſment of the chromatic and enharmonic ſcales of the lyre. It is ſcarcely poſſible to contrive a more cumberſome method of extending the ſimple ſcale of Nature to every caſe that could occur in their muſical compoſitions, than what aroſe from the employment of the muſical ratios. This ſeems a bold aſſertion; but we apprehend that it will appear to be juſt as we proceed.

24
The tranſpoſition of muſic made intercalary notes neceſſary in the octave.

The practical muſicians could not be long of finding the want of ſomething more than the mere diatonic ſcale of their inſtruments. As they were always accompanied by the voice, it would often happen that a lyre or flute, perfectly tuned, was too low or too high for the voice that was to accompany it. A ſinger can pitch his tune on any ſound as a key; and if this be too high for the ſinger who is to accompany him, he can take it on a lower note. But a lyriſt cannot do this. Suppoſe his inſtrument two notes too low, and that his accompanyiſt can only ſing it on the key which is the *ſi* of the lyre. Should the lyriſt begin it on that key, his very firſt ſtep is wrong, being but a half ſtep, whereas it ſhould be a whole one. In ſhort, all the ſteps but one will be found wrong, and the lyriſt and ſinger will be perpetually jarring. This is an evident conſequence of the inequality of the fourth and ſeventh ſteps to the reſt. And if the other ſteps, which we imagine to be equal, be not exactly ſo, the diſcordance will be ſtill greater.

Diſputes of the Pythagoreans and Ariſtoxenians about muſical intervals.

The method of remedying this is very obvious. If the intervals *mi fa* and *ſi do*, are half notes, we need only to interpoſe other ſounds in the middle between each of the whole notes; and then, in place of ſeven unequal ſteps, we ſhall have twelve equal ones, or twelve intervals, each of them equal to a ſemitone. The lyre thus conſtructed will now ſuit any voice whatever. It will perfectly reſemble our keyed inſtruments, the harpſichord, or organ, which have twelve ſeemingly equal intervals in the octave. Accordingly, it appears that ſuch additions were practiſed by the muſicians of Greece, and approved of by Ariſtoxenus, and by all thoſe who referred every thing to the judgment of the ear. And we are confident that this method would have been adopted, if the philoſophers had had leſs influence, or if the Greeks had not borrowed their religious ceremonies along with their muſical ſcience. Both of theſe came from the ſame quarter; they came united; and it was ſacrilegious to attempt innovations. The doctrine of muſical ratios was an occupation only for the refined, the philoſophers; and by ſubjecting muſic to this myſterious ſcience, it became myſterious alſo, and ſo much the more venerable. The philoſophers ſaw, that there was in Nature a certain inſcrutable connection between mathematical ratios and thoſe intervals which the ear reliſhed and required in melody: but they were ignorant of the nature and extent of this connection.

Ratios of octave, diapente, and diateſſaron.

What is this connection, or what is meant when we ſpeak of the ratios of ſounds? Simply this:—Pythagoras is ſaid to have found, that if two muſical cords be ſtrained by equal weights, and one of them be twice the length of the other, the ſhort one will ſound the octave to the note of the other. If it be two-thirds of the length of the long ſtring, it will ſound the fifth to it. If the long ſtring ſound *do*, the ſhort one will ſound *ſol*. If it be three-fourths of the length, it will ſound the fourth or *fa*. Thus the ratio of 2 : 1 was called the ratio of the DIAPASON; that of 3 : 2 was called the DIAPENTE; and that of 4 : 3 the DIATESSARON. Moreover, if we now take all the four ſtrings, and make that which ſounds the graveſt note, and is the longeſt, twelve inches in length; the ſhort or octave ſtring muſt be ſix inches long, or one-half of twelve; the diapente muſt be eight inches, or two-thirds of twelve; and the diateſſaron muſt be nine inches, which is three-fourths of twelve. If we now compare the diapente, not with the graveſt ſtring, but with the octave of ſix inches, we ſee that they are in the ratio of 4 to 3, or the ratio of diateſſaron. And if we compare the diateſſaron with the

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the octave, we see that their ratio is that of 9 : 6, or of 3 : 2, or the ratio of diapente. Thus is the octave divided into a fifth and a fourth, *do sol*, and *sol do*, in succession. Also the fourth *do fa*, and the fifth *fa do*, make up the octave. The note which stands as a fifth to one of the extreme sounds of the octave, stands as a fourth to the other. And, lastly, the two fourths *do fa*, and *sol do*, leave an interval *fa sol* between them; which is also determined by nature, and the ratio corresponding to it is evidently that of 9 to 8.

The discovery of Pythagoras is called a fable, or fabulously narrated.

This is all that was known of the connection of music with mathematical ratios. It is indeed said by Iamblichus, that Pythagoras did not make this discovery by means of strings, but by the sounds made by the hammers on the anvil in a smith's shop. He observed the sounds to be the key, the diatessaron, and the diapente of music; and he found, that the weights of the hammers were in this proportion; and as soon as he went home, he tried the sounds made by cords, when weights, in the proportions above mentioned, were appended to them. But the whole story has the air of a fable, and of ignorance. The sounds given by a smith's anvil have little or no dependence on the weight of the hammers; and the weights which are in the proportions of the numbers mentioned above will by no means produce the sounds alleged. It requires *four* times the weight to make a string sound the octave, and *twice and a quarter* will produce the diapente, and *one and seven-ninths* will produce the diatessaron. It is plain, therefore, that they knew not of what they were speaking: yet, on this slight foundation, they erected a vast fabric of speculation; and in the course of their researches, these ratios were found to contain all that was excellent. The attributes of the Divinity, the symmetry of the universe, and the principles of morality, were all resolvable into the harmonic ratios.

26
Conjoined and disjoined tetrachords.

In the attempts to explain, by means of the mysterious properties of the ratios 2 : 1, 3 : 2, 4 : 3, and 9 : 8, which were thus defined by Nature, it was observed, that their favourite lyres of four strings could be combined in two principal manners, so as to produce an extensive scale. One lyre may contain the notes *do, re, mi, fa*; and the acuter lyre may contain the notes *sol, la, si, do*; and, being set in succession, having the interval *fa sol* between the highest note of the one and the lowest of the other, they make a complete octave. These were called *disjoined tetrachords*. Again, a third tetrachord may be joined with the upper tetrachord last mentioned, in such sort, that the lowest note of the third tetrachord may be the same with the highest of the second. These were called *conjoined* tetrachords (A).

The lyres were tuned chiefly by the ear,

By thus considering the scale as made up of tetrachords, the tuning of the lyre was reduced to great simplicity. The musician had only to make himself perfect in the short chaunt *do, re, mi, fa*, or to get it by heart, and to sing it exactly. This intonation would apply equally to the other *sol, la, si, do*. We are well informed that this was really the practice. The directions given by Aristoxenus, Nicander, and others, for varying the tuning, according to certain occasional accommodations, shew distinctly that they did not tune as we do, sounding the two strings together, except in the case of the diapason or octave. It was all done by the judgment of the ear in melody. The most valuable circumstance in the discovery of Pythagoras was the determination of the interval between the fourth and the fifth, by which the tetrachords were separated. The filling up of each tetrachord was left entirely to the ear; and when the doctrine of the mathematical ratios shewed that the large intervals *do re, re mi, fa sol, sol la, la si*, should not be precisely equal, Aristoxenus refused the authority of the reasons alleged for this inequality, because the ear perceived none of the ratios as ratios, and could judge only of sounds. He farther asserted, that the inequalities which the Pythagoreans enjoined, were so trifling, that no ear could possibly perceive them. And accordingly, the theorists disputed about the respective situations of the greater and smaller tones (so they named the great steps) so much spoken of, and had different systems on the subject.

And by melody alone: 28

But the strongest proof of the indistinct notion that the theorists entertained about the influence of these ratios in music is, that they would admit no more but those introduced by Pythagoras; and their reasons for the rejection of the ratio of 5 to 4, and of 6 to 5, were either the most whimsical fancies about the perfections of the sacred ratios, or assumptions expressly founded on the supposition, that the ear perceives and judges of the ratios as ratios; than which nothing can be more false. Had they admitted the ratio of 5 to 4, they would have obtained the third note of the scale, and would at once have gotten the whole scale of our music. The ratios of 6 : 5, and 16 : 15, follow of course; and every sound of the tetrachords would have been determined. For 5 : 4 being the ratio of the major third, which is perfectly pleasing to the ear, as the *mi* to the note *do*, and 3 : 2 being the ratio of the fifth *do sol*, there is another interval *mi sol* determined; and this ratio, being the difference between *do sol* and *do mi*, or between 3 : 2 and 5 : 4, is evidently 6 : 5. In like manner, the interval *mi fa* is determined, and its ratio, being 4 : 3 — 5 : 4, is 16 : 15.

But farther; we shall find, upon trial, that if we put in a sound above *sol*, having the relation 5 : 4 to *fa*, it will be perfectly satisfactory to the ear if sung as the note *la*. And if, in like manner, we put in a note above *la*, having the relation 5 : 4 to *sol*, we find it satisfactory to the ear when used as *si*. If we now examine the ratios of these artificial notes, we shall find the ratio of the notes *sol la* to be 10 : 9, and that of *la si* to be 9 : 8, the same with that *fa sol*; also *si do* will appear to be 16 : 15, like that of *mi fa*.

We have no remains of the music of the Greeks, by which we can learn what were their favourite passages or musical phrases; and we cannot see what caused them to prefer the fourth to the major third. Few musicians of our times think the fourth in any degree comparable with the major third for melodiousness, and still fewer for harmoniousness. The piece or tune published by Kircher from Alypius is very suspicious, as no

(A) This is the *principle*, but not the precise *form*, of the disjoined and conjunct tetrachords. The Greeks did not begin the tetrachord with what we make the first note of our chaunt of four notes, but began one of them with *mi*, and the other with *si*; to which they afterwards added a note below. This beginning seems to have been directed by some of their favourite cadences; but it would be tedious to explain it.

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no other person has seen the MS; and the collection found at Buda is too much disfigured, and probably of too late a date, to give us any solid help. In all probability, the common melodies of the Greeks abounded in easy leaps up and down on the third and fifth, and on the fourth and sixth, just as we observe in the airs for dancing among all simple people. Their accomplished performers had certainly great powers both of invention and execution; and the chromatic and enharmonic divisions of the scale were certainly practised by them, and not merely the speculations of mathematicians. To us, the enharmonic scale appears the most jarring discord; but this is certainly owing to our not seeing any pieces of the music so composed, and because we cannot in the least judge by harmony what the effect of enharmonic melody would be. But we have sufficient from the writings of the ancient Greeks, that the enharmonic music fell into disuse even before the time of Ptolemy, and was totally and irrecoverably lost before the 5th century. Even the chromatic was little practised, and was chiefly employed for extending the common scale to keys which were seldom used. The uncertainties respecting even the common scale remained the same as ever; and although Ptolemy gives (among others) the very same that is now admitted as the only perfect one, namely, his *diatonicum intensum*, his reasons of preference, though good, are not urged with strong marks of his confidence in them, nor do they seem to have prevailed.

29 But melody is quite insufficient.

These observations shew clearly, that the perception of melody alone is not sufficiently precise for enabling us to acquire exact conceptions of the scale of music. The whole of the practicable science of the ancients seems to amount to no more than this, that the octave contained five greater and two smaller intervals, which the voice employed, and the ear relished. The greater intervals seemed all of one magnitude; and the smaller intervals appeared also equal, but the ear cannot judge what proportion they bear to the larger ones. The musicians thought them larger than one-half of the great intervals (and indeed the ratio 16 : 15 of the artificial *mi fa* and *si do*, is greater than the half of 9 : 8 or 10 : 9). Therefore they allowed the theorists to call them *limmas* instead of *hemitones*; but they, as well as the theorists, differed exceedingly in the magnitudes which they assigned them.

30 Circular representation of the scale. Plate XLIV

The best way that we can think of for expressing the scale of the octave is, by dividing the circumference of a circle in the points C, D, E, F, G, A, and B (fig. 1.), in the proportion we think most suitable to the natural scale of melody. According to the practical notion now under our consideration, the arches CD, DE, FG, GA, and AB, are equal, containing nearly 59°; and the arches EF and BC are also equal, but smaller than the others, containing about 33½. Now, suppose another circle, on a piece of card paper, divided in the same manner, to move round their common centre, but instead of having its points of division marked C, D, E, &c. let them be marked *do, re, mi, fa, sol, la, si*. It is plain, that to whatever point of the outer circle we set the point *do* of the inner one, the other points of the outer circle will shew the common notes which are fit for those steps of the scale. The similarity of all octaves makes this simple octave equivalent to a rectilineal scale similarly divided, and repeated as often as we please. Fig. 1. represents this instrument, and will be often referred to. A sort of symmetry may be observed in it. The point D seems to occupy the middle of the scale, and *re* seems to be the middle note of the octave. The opposite arch GA, and the corresponding interval *sol la*, seems to be the middle interval of the octave. The other notes and intervals are similarly disposed on each side of these. This circumstance seems to have been observed by the Greeks, by the inhabitants of India, by the Chinese, and even by the Mexicans. The note *re*, and the interval *sol la*, have gotten distinguished situations in their instruments and scales of music.

31 Aristoxenean division of the circle.

With respect to the division of the circles, we shall only observe at present, that the dotted lines are conformable to the principles of Aristoxenus, the whole octave being portioned out into five larger and equal intervals, and two smaller, also equal. The larger are called *mean* or *medium tones*; and the smaller are called *limmas* or *semitones*. The full lines, to which the letters and names are affixed, divide the octave into the artificial portions, determined by means of the musical ratios, the arches being made proportional to the measures of those ratios. Thus the arches CD, FG, AB, are proportional to the measure or logarithm of the ratio 9 : 8; GA and DE are proportional to the logarithm of 10 : 9; and the arches EF and BC are proportional to the logarithm of 16 : 15. We have already mentioned the way in which those ratios were applied, and the authority on which they were selected. We shall have occasion to return to this again. The only farther remark that is to be made with propriety in this place is, that the division on the Aristoxenean principles, which is expressed in this figure, is one of an indefinite number of the same kind. The only principle adopted in it is, that there shall be five mean tones, and two small equal semitones; but the magnitude of these is arbitrary. We have chosen such, that two mean tones are exactly equal to the arch CE, determined by the ratio 5 : 4. The reasons for this preference will appear as we proceed (B).

By this little instrument (the invention, we believe, of a Mr D'Ormisson, about the beginning of last century), we see clearly the insufficiency of the seven notes of the octave for performing music on different keys. Set the flower de luce at the Aristoxenean B, and we shall see that E is the only note of our lyre which will do for one of the steps of the octave in which we intend to sing and accompany. We have no sounds in the lyre for *re, mi, sol, la, si*. The remedy is as clearly pointed out. Let a set of strings be made, having the same relation to *si* which those of the present lyre have to *do*, and insert them in the places pointed out by the Aristoxenean divisions of the moveable octave. We need only five of them, because the *si* and *fa* of the present lyre will answer. These new sounds are marked by a +.

32 Found imperfect and determinate.

But it was soon found, that these new notes gave but indifferent melody, and that either the ear could not determine

(B) We shall be abundantly exact, if we make CD = 61°,72; CE = 115°,9; CF = 149°,42; CG = 210°,58; CA = 263°,3; and CB = 326°,48.

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determine the equality of the tones and ſemitones exactly enough, or that no ſuch partition of the octave would anſwer. The Pythagoreans, or partiſans of the muſical ratios, had told them this before. But they were in no better condition themſelves; for they found, that if a ſeries of ſounds, in perfect relation to the octave, be inſerted in the manner propoſed, the melody will be no better. They put the matter to a very fair trial. It is eaſy to ſee, that no ſyſtem of mean tones and limmas will give the ſame muſic on every key, unleſs the tones be increaſed, and the limmas diminiſhed, till the limma becomes juſt half a tone. Then all the intervals will be perfectly equal. The mathematicians computed the ratios which would produce this equality, and deſired the Ariſtoxeneans to pronounce on the muſic. It is ſaid, that they allowed it to be very bad in all their moſt favourite paſſages. Nothing now remained to the Ariſtoxeneans but to attempt occaſional methods of tuning. They ſaw clearly, that they were making the notes unequal which Nature made equal. The Pythagoreans, in like manner, pointed out many alterations or corrections of intervals which ſuited one tetrachord, or one part of the octave, but did not ſuit another. Both parties ſaw that they were obliged to deviate from what they thought natural and perfect: therefore they called theſe alterations of the natural or perfect ſcale a *temperament*.

The accompliſhed performers were the beſt judges of the whole matter, and they derived very little aſſiſtance from the mathematicians: For although the rigid rules delivered by them be acknowledged to be perfectly exact, the execution of thoſe rules is not ſuſceptible of the ſame exactneſs. Their lyres are tuned, not by mathematical operations, but by the ear. It does not appear that they had muſical inſtruments with divided finger-boards, like our baſs viols and guitars; and even on theſe, it is well known that the preſſure and touch of the finger may vary ſo much, that the moſt exact placing of the frets will not inſure the nice degrees of the ſounds. The flutes are the only inſtruments of the ancients that are capable of accurate ſounds. But flutemakers know very well, that they cannot be tuned by mathematical operations, but by the ear alone. This accounts for the great prices paid for a well-tuned flute. Some have coſt L. 700, and L. 50 was a very common price.

33 The Greeks did not cultivate the harmony of ſimultaneous ſounds.

Such ſeems to have been the ſtate of the ancient muſic. There was little or no ſcience in it. There was, indeed, a moſt abſtruſe and refined ſcience coupled with it; but by a very ſlight connection: and it ſeems to have been nothing more than an amuſement for the ingenious and ſpeculative Greeks. Nor could it, in our opinion, be better, ſo long as they had no guide in tuning but the judgment of the ear in melody. Many writers inſiſt that the Greeks had a knowledge of what *we* call *harmony* alſo. The word ἁρμονια is conſtantly uſed by them: but it does not mean what we call harmony, the pleaſant coaleſcence of ſimultaneous ſounds. It comes from ἁρμος, or from ἁρμοζω, and ſignifies *aptitude, fitneſs*, and would, in general, be better tranſlated by *ſymmetry*. But we cannot conceive that they paid any marked attention to the effect of ſimultaneous ſounds, ſo as to enjoy the pleaſure of certain conſonances, and employ them in their compoſitions. We judge in this way from the rank which they gave them in their ſcale. To prefer the fourth to the major third ſeems to us to be impoſſible, if it be meant of ſimultaneous ſounds. And the reaſon which is aſſigned for the preference can have no value in the opinion of a muſician. It is becauſe the ratio of 4 : 3 is ſimpler than that of 5 : 4. For the ſame reaſon, the fifth is preferred to both, and the octave to all the three, and uniſon to every other conſonance. They would not allow the major third 5 : 4 to be a concord at all. We have made numberleſs trials of the different concords with perſons altogether ignorant of muſic. We never ſaw an inſtance of one who thought that mere uniſon gave any poſitive pleaſure. None of all whom we examined had much pleaſure from an octave. All, without exception, were delighted with a fifth, and with a major third; and many of them preferred the latter. All of them agreed in calling the pleaſure from the fifth a *ſweetneſs*, and that from the major third a *cheerfulneſs*, or *ſmartneſs*, or by names of ſimilar import. The greater part preferred even the major ſixth to the fourth, and ſome felt no pleaſure at all from the fourth. Few had much pleaſure from the minor third or minor ſixth. *N. B.* Care was taken to ſound theſe concords without any preparation—merely as ſounds—but not as making part of any muſical paſſage. This circumſtance has a great effect on the mind. When the minor third and ſixth were heard as making part of the minor mode, all were delighted with it, and called it ſweet and mournful. In like manner, the chord $\frac{6}{4}$ never failed to give pleaſure. Nothing can be a ſtronger proof of the ignorance of the ancients of the pleaſures of harmony.

34 The pleaſures of harmony ſeem to be a modern diſcovery.

We do not profeſs to know when this was diſcovered. We think it not unlikely that the Greeks and Italians got it from ſome of the northern nations whom they called *Barbarians*. We cannot otherwiſe account for its prevalence through the whole of the Ruſſian empire—the ancient Slavi had little commerce with the empire of Rome or of Conſtantinople; yet they ſung in parts in the moſt remote periods of their hiſtory of which we have any account; and to this day, the moſt uncultivated boor in the Ruſſian empire would be aſhamed to ſing in uniſon. He liſtens a little while to a new tune, holding his chin to his breaſt; and as ſoon as he has got a notion of it, he burſts out in concert, throwing in the harmonic notes by a certain rule which he feels, but cannot explain. His harmonics are generally alternate major and minor thirds, and he ſeldom miſſes the proper cadences on the fifth and key. Perhaps the invention of the organ produced the diſcovery. We know that this was as early as the ſecond century (c). It was hardly poſſible to make much uſe of that inſtrument without perceiving the pleaſure of concordant ſounds.

The

(c) It is ſaid that the Chineſe had an inſtrument of this kind long before the Europeans. Cauſeus ſays, that it was brought from China by a native, and was ſo ſmall as to be carried in the hand. It is certain that the Emperor Conſtantine Copronymus ſent one to Pepin king of France in 757, and that his ſon Charlemagne got another from the Emperor Michael Paleologus. But they appear to have been known in the Engliſh churches before that time.

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35 Harmony made a great change in the science of music.

The discovery of the pleasures of harmony occasioned a total change in the science of music. During the dark ages of Europe, it was cultivated chiefly by the monks: the organ was soon introduced into the churches, and the choral service was their chief and almost their only occupation. The very construction of this instrument must have contributed to the improvement of music, and instructed men in the nature of the scale. The pipes are all tuned by their lengths; and these lengths are in the ratios of the strings which give the same notes, when all are equally stretched. This must have revived the study of the musical ratios. The tuning of the organ was performed by consonance, and no longer depended on the nice judgment of sounds in succession. The dullest ear, even with total ignorance of music, can judge, without the smallest error, of an exact octave, fifth, third, or other concord; and a very mean musician could now tune an organ more accurately than Timotheus could tune his lyre. Other keyed instruments, resembling our harpsichord, were invented, and instruments with fretted finger boards. These soon supplanted the lyres and harps, being much more compendious, and allowing a much greater variety and rapidity of modulation. All these instruments were the fruits of harmony, in the modern sense of that word. The deficiences of the old diatonic scale were now more apparent, and the necessity of a number of intercalary notes. The finger-board of an organ or harpsichord, running through a series of octaves, and admitting much more than the accompanyment of one note, pointed out new sources of musical pleasure arising from the fulness of the harmoy; and, above all, the practice of choral singing suggested the possibility of a pleasure altogether new. While a certain number of the choir performed the Cantus or Air of the music, it was irksome to the others to utter mere sounds, supporting or composing the harmony of the Cantus, without any melody or air in their own parts. It was thought probable that the harmonic notes might be so portioned out among the rest of the choir, that the succession of sounds uttered by each individual might also constitute a melody not unpleasant, and perhaps highly grateful. On trial, it was found very practicable. Canons, motets, fugues, and other harmonies, were composed, where the airs performed by the different parts were not inferior in beauty to the principal. The notes which could not be thrown into this agreeable succession, were left to the organist, and by him thrown into the bass.

36. By all these practices, the imperfections of the scale of fixed sounds became every day more sensible, especially in full harmony. Scientific music, or the properties of the ratios, now recovered the high estimation in which they were held by the ancient theorists; and as the musicians were now very frequently men of letters, chiefly monks, of sober characters and decent manners, music again became a respectable study. The organist was generally a man of science, as well as a performer. At the first revival of learning in Europe, we find music studied and honoured with degrees in the universities, and very soon we have learned and excellent dissertations on the principles of the science. The inventions of Guido, and the dissertations of Salinas, Zarlino, and Xoni, are among the most valuable publications that are extant on music. The improvements introduced by Guido are founded on a very refined examination of the scale; and the temperaments proposed by the other two have scarcely been improved by any labours of modern date. Both these authors had studied the Greek writers with great care, and their improvements proceed on a complete knowledge of the doctrines of Pythagoras and Ptolemy.

37 Galileo's [illegible]

At last the celebrated Galileo Galilei put the finishing hand to the doctrines of those ancient philosophers, by the discovery of the connection which subsists in nature between the ratios of numbers and the musical intervals of sounds. He discovered, that these numbers express the frequency of the recurring pulses or undulations of air which excite in us the sensation of sound. He demonstrated that if two strings, of the same matter and thickness, be stretched by equal weights, and be twanged or pinched so as to vibrate, the times of their vibrations will be as their lengths, and the frequency or number of oscillations made in a given time will be inversely as their lengths. The frequency of the sonorous undulations of the air is therefore inversely as the length of the string. When therefore we say that 2 : 1 is the ratio of the octave, we mean, that the undulations which produce the upper sound of this interval are twice as frequent as those which produce its fundamental sound. And the ratio 3 : 2 of the diapente or fifth, indicates, that in the same time that the ear receives three undulations from the upper sound, it receives only two from the lower. Here we have a natural connection, not peculiar to the sounds produced by strings; for we are now able to demonstrate, that the sounds produced by bells are regulated by the same law. Nay, the improvements which have been made in the science of motion since the days of Galileo, shew us that the undulations of the air in pipes, where the air is the *only* substance moved, is regulated by the same law. It seems to be the general property of sounds which renders them susceptible of musical pitch, of acuteness, or gravity; and that a certain frequency of the sonorous undulations gives a determined and unalterable musical note. The writer of this article has verified this by many experiments. He finds, that *any noise whatever*, if repeated 240 times in a second, at equal intervals, produces the note C *sol fa ut* of the Guidonian gamut. If it be repeated 360 times, it produces the G *sol re ut*, &c. It was imagined, that only certain regular agitations of the air, such as are produced by the tremor or vibration of elastic bodies, are fitted for exciting in us the sensation of a musical note. But he found, by the most distinct experiments, that any noise whatever will have the same effect, if repeated with due frequency, not less than 30 or 40 times in a second. Nothing surely can have less pretension to the name of a musical sound than the solitary snap which a quill makes when drawn from one tooth of a comb to another: but when the quill is held to the teeth of a wheel, whirling at such a rate, that 720 teeth pass under it in a second, the sound of *g in alt.* is heard most distinctly; and if the rate of the wheel's motion be varied in any proportion, the noise made by the quill is mixed in the most distinct manner with the musical note corresponding to the frequency of the snaps. The *kind* of the original noise determines the kind of the continuous sound produced by it, making it harsh and fretful, or smooth and mellow, according as the original noise is abrupt or gradual: but even the most abrupt noise

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noise produces a tolerably smooth sound when sufficiently frequent. Nothing can be more abrupt than the snap just now mentioned; yet the *g* produced by it has the smoothness of a bird's chirrup. An experiment was made, which was less promising of a sound than any that can be thought of. A stop cock was so constructed, that it opened and shut the passage through a pipe 720 times in a second. This apparatus was fitted to the pipe of a conduit leading from the bellows to the wind chest of an organ. The air was simply allowed to pass gently along this pipe by the opening of the cock. When this was repeated 720 times in a second, the sound *g in alt.* was most smoothly uttered, equal in sweetness to a clear female voice When the frequency was reduced to 360, the sound was that of a clear but rather harsh man's voice. The cock was now altered in such a manner, that it never shut the hole entirely, but left about one third of it open. When this was repeated 720 times in a second, the sound was uncommonly smooth and sweet. When reduced to 360, the sound was more mellow than any man's voice at the same pitch. Various changes were made in the form of the cock, with the intention of rendering the primitive noise more analogous to that produced by a vibrating string. Sounds were produced which were pleasant in the extreme. The intelligent reader will see here an opening made to great additions to practical music, and the means of producing musical sounds, of which we have at present scarcely any conception; and this manner of producing them is attended with the peculiar advantage, that an instrument so constructed can never go out of tune in the smallest degree. But of this enough at present.

38 This frequency is express'd by the musical ratios of Pythagoras.

This discovery of Galileo's completed the Pythagorean theories, by supplying the only thing wanted for procuring confidence in them. We now see that the music of sounds depends on principles as certain and as plain as the elements of Euclid, and that every thing relating to the scale of music is attainable by mathematics. It is very true that we do not perceive the ratio 3 : 2 in the diapente, as having any relation to the numbers 3 and 2. But we perceive the sweetness of sound which characterises this concord. This is undoubtedly the perception of a certain physical fact involving this ratio, as much as the sweetness on our tongue is the perception of a certain manner of acting of the particles of sugar during their dissolution in the saliva.

Concord, discord, are properties of particular ratios of frequency

The pleasure arising from certain consonances, such as *do sol*, is not more distinctly perceived than is the disagreeable feeling which other consonances produce, such as *do re*; and it was a fair field of disquisition to discover why the one pleased and the other displeased. We cannot say that this question has been completely decided. It has been ascribed to the coincidence of vibrations. In the octave, every second vibration of the treble note may be made to coincide with every vibration of the bass. But the pleasure arising from the different consonances does by no means follow the proportions of these coincidences of vibrations; for when two notes are infinitely near to the state which would produce a complete coincidence, the actual coincidence is then exceedingly rare; and yet we know that such sounds yield very fine harmony. In tuning any concord, when the two notes are very discordant, the coinciding vibrations recur very frequently; and as we approach nearer and nearer to perfect concord, these coincidences become rarer and rarer; and if it be infinitely near to perfect concord, the coincidences of vibration will be infinitely distant from each other. This, and many other irrefragable arguments, demonstrate that coalescence of sound, which makes the pleasing harmony of a fifth, for example, does not arise from the coincidence of vibrations; and the only thing which we can demonstrate to obtain in all the cases where we enjoy this pleasure, is a certain arrangement of the component pulses, and a certain law of succession of the dislocations or intervals between the non-coinciding pulses. We are perfectly able to demonstrate that when, by continually screwing up one of the notes of a consonance, we render the real coincidence of pulses less frequent; the dislocations, or deviations from perfect coincidence, approach nearer and nearer to a certain defineable law of succession; and that this law obtains completely, when the perfect ratio of the duration of the pulse is attained, although perhaps at that time not one pulse of the one sound coincides with a pulse of the other. Suppose two organ pipes, sounding the note C *sol fa ut*, at the distance of ten feet from each other, and that their pulses begin and end at the same instants, making the most perfect coincidence of pulses—there is no doubt but that there will be the most perfect harmony; and we learn by experience that this harmony is perfectly the same, from whatever part of the room we hear it. This is an unquestionable fact. A person situated exactly in the middle between them will receive coincident pulses. But let him approach one foot nearer to one of the pipes, it is now demonstrable that the pulses, at their arrival at his ear, will be the most distant from coincidence that is possible; for every pulse of one pipe will bisect the pulse from the other: but the law of succession of the deviations from coincidence will then obtain in the most perfect manner. A musical sound is the sensation of a certain form of the aerial undulation which agitates the auditory organ. The perception of harmonious sound is the sensation produced by another definite form of the agitation. This is the composition of two other agitations; but it is the compound agitation only that affects the ear, and it is its form or kind which determines the sensation, making it pleasant or unpleasant.

Hence arises the great use of mathematics in music. 39

Our knowledge of mechanics enables us to describe this form, and every circumstance in which one agitation can differ from another, and to discover general features or circumstances of resemblance, which, in fact, accompany all perceptions of harmony. We are surely intitled to say that these circumstances are sure tests of harmony; and that when we have ensured their presence, we have ensured the hearing of harmony in the adjusted sounds. We can even go farther in some cases: We can explain some appearances which accompany imperfect harmony, and perceive the connection between certain distinct results of imperfect coincidences, and the magnitude of the deviations from perfect harmony which are then heard. Thus, we can make use of these phenomena, in order to ascertain and measure those deviations; and if any rules of temperament should require a certain determinate deviation from perfect harmony in the tuning of an instrument, we can secure the appearance of that phenomenon which corresponds to the deviation, and thus can produce the precise temperament

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rament suggested by our rules. We can, for example, destroy the perfect harmony of the fifth C *g*, and flatten the note *g* till it deviates from a perfect fifth in the exact ratio of 320 to 321, which the musicians call the one-fourth of a comma. The most exquisite ear for melody is almost insensible of a deviation four times greater than this; and yet a person who has no musical ear at all, can execute this temperament by the rules of harmony without the error of the fortieth part of a comma.

40
Beatings of imperfect consonances.

For this most valuable piece of knowledge we are indebted to the late Dr Robert Smith of Cambridge, a very eminent geometer and philosopher, and a good judge of music, and very pleasing performer on the organ and harpsichord. This gentleman, in his Dissertation on the Principles of Harmonics, published for the first time in 1749, has paid particular attention to a phenomenon in coexistent sounds, called a *beating*. This is an alternate enforcement and diminution of the strength of sound, something like what is called a close shake, but differing from it in having no variation in the pitch of the sounds. It is a sort of undulation of the sound, in which it becomes alternately louder and fainter. It may be often perceived in the sound of bells and musical glasses, and also in the sounds of particular strings. It is produced in this way: Suppose two unisons quite perfect; the vibrations of each are either perfectly coincident, or each pulse of one sound is interposed in the same situation between each pulse of the other. In either case they succeed each other with such rapidity, that we cannot perceive them, and the whole appears an uniform sound. But suppose that one of the sounds has 240 pulses in a second, which is the undulation that is produced in a pipe of 24 inches long; suppose that the other pipe is only 23 inches and $\frac{7}{10}$ths long. It will give 243 pulses in a second. Therefore the 1st, the 80th, the 160th, and the 240th pulse of the first pipe will coincide with the 1st, the 81st, the 162d, and the 243d pulse of the other. In the instants of coincidence, the agitation produced by one pulse is increased by that produced by the other. The commencement of the next two pulses is separated a little, and that of the next is separated still more, and so on continually: the *dislocations* of the pulses, or their deviations from perfect coincidence, continually increasing, till we come to the 40th pulse of the one pipe, which will commence in the middle of the 41st pulse of the other pipe; and the pulses will now bisect each other, so that the agitations of the one will counteract or weaken those of the other. Thus the compounded sound will be stronger at the coincidences of the pulses, and fainter when they bisect each other. This reinforcement of sound will therefore recur thrice in every second. The frequency of the pulses are in the ratio of a comma, or 81 : 80. Therefore this constitutes an *unison imperfect by a comma*. If therefore any circumstance should require that these two pulses should form an unison imperfect by a comma, we have only to alter one of the pipes, till the two, when sounded together, beat thrice in a second. Nothing can be plainer than this. Now let us suppose a third pipe tuned an exact fifth to the first of these two. There will be no beating observable; because the recurrence of coincident pulses is so rapid as to appear a continued sound. They recur at every second vibration of the bass, or 120 times in a second. But now, instead of sounding the third pipe along with the first, let it sound along with the second. Dr Smith demonstrates, that they will beat in the same manner as the unisons did, but thrice as often, or nine times in a second. When therefore the fifth C *g* beats nine times in a second, we know that it is too sharp or too flat (very nearly) by a comma.

41
Dr Smith applies them to the science and practice of music with great effect.

Dr Smith shews, in like manner, what number of beats are made in any given time by any concord, imperfect or tempered, in any assigned degree. We humbly think that the most inattentive person must be sensible of the very great value of this discovery. We are obliged to call it *his* discovery. Mersennus, indeed, had taken particular notice of this undulation of imperfect consonances, and had offered conjectures as to their cause; conjectures not unworthy of his great ingenuity. Mr Sauveur also takes a still more particular notice of this phenomenon *, and makes a most ingenious use of it for the solution of a very important musical problem; namely, to determine the precise number of pulses which produce any given note of the gamut. His method is indeed operose and delicate, even as simplified and improved by Dr Smith. The following may be substituted for it, founded on the mechanism of sounding cords. Let a violin, guitar, or any such instrument, be fixed up against a wall, with the finger-board downward, and in such a manner, that a violin string, strained by a weight, may press on the bridge, but hang free of the lower end of the finger board. Let another string be strained by one of the tuning pins till it be in unison with some note (suppose C) of the harpsichord. Then hang weights on the other string, till, upon drawing the bow across both strings, at a small distance below the bridge, they are perfect unisons, without the smallest beating or undulation, and taking care that the pressure of the bow on that string which is tuned by the pin be so moderate as not to affect its tension sensibly. Note exactly the weight that is now appended to it. Now increase this weight in the proportion of the square of 80 to the square of 81; that is, add to it its 40th part very nearly. Now draw the bow again across the strings with the same caution as before. The sounds will now beat remarkably; for the vibrations of the loaded string are now accelerated in the proportion of 80 to 81. Count the number of undulations made in some small number (suppose 10) of seconds. This will give the number of beats in a second; 80 times this number are the single pulses of the lowest sound; and 81 times the same number gives the pulses of the highest of these imperfect unisons.

Pulses of [illegible] = 240.

* Mem. Acad. Par. 17[illegible], 1702, 17[illegible], and 171[illegible]

If this experiment be tried for the C in the middle of our harpsichords, it will be found to contain 240 pulses very nearly; for the strings will beat thrice in a second. The beats are best counted by means of a little ball hung to a thread, and made to keep time with the beats.

42
They afford exact measures of the temperament of concords.

Here, then, is a phenomenon of the most easy observation, and requiring no skill in music, by which the pitch of any sound, and the imperfection of any concord, may be discovered with the utmost precision; and by this method may concordant sounds be produced, which are absolutely perfect in their harmony, or having any degree of imperfection or temperament that we please. An instrument may generally be tuned to perfect harmony, in some of its notes, without any dif-

ficulty,

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ficulty, as we see done by every blind Crouder. But if a certain determinate degree of imperfection, different perhaps in the different concords, be necessary for the proper performance of musical compositions on instruments of fixed sounds, such as those of the organ or harpsichord kind, we do not see how it can be disputed, that Dr Smith's theory of the beating of imperfect consonances is one of the most important discoveries, both for the practice and the science of music, that have been offered to the public. We are inclined to consider it as the most important that has been made since the days of Galileo. The only rivals are Dr Brook Taylor's mechanical demonstration of the vibrations of an elastic cord, and its companion, and of the undulations of the air in an organ pipe, and the beautiful investigations of Daniel Bernoulli of the harmonic sounds which frequently accompany the fundamental note. The musical theory of Rameau we consider as a mere whim, not founded in any natural law; and the theory of the grave harmonics by Tartini or Romieu is included in Dr Smith's theory of the beating of imperfect consonances. This theory enables us to execute any harmonic system of temperament with precision, and certainty, and ease, and to decide on its merit when done.

We are therefore surprised to see this work of Dr Smith greatly undervalued, by a most ingenious gentleman in the Philosophical Transactions for 1800, and called a large and obscure volume, which leaves the matter just as it was, and its results useless and impracticable. We are sorry to see this; because we have great expectations from the future labours of this gentleman in the field of harmonics, and his late work is rich in refined and valuable matter. We presume humbly to recommend to him attention to his own admonitions to a very young and ingenious gentleman, who, he thinks, proceeded too far in animadverting on the writings of Newton, Barrow, and other eminent mathematicians. We also beg his leave to observe, that Dr Smith's application of his theory may be very erroneous (we do not say that it is perfect), in consequence of his notion of the proportional effects produced on the general harmony by equal temperaments of the different concords. But the theory is untouched by this improper use, and stands as firmly as any proposition in Euclid's Elements. We are bound to add to these remarks, that we have oftener than once heard music performed on the harpsichord described in the second edition of Dr Smith's Harmonics, both before it was sent home by the maker (the first in his profession), and afterwards by the author himself, who was a very pleasing performer, and we thought its harmony the finest we ever heard. Mr Watt, the celebrated engineer, and not less eminent philosopher, built a handsome organ for a public society, and, without the least ear or relish for music, tuned three octaves of the open diapason by one of Dr Smith's tables of beats, with the help of a variable pendulum. Signior Doria, leader of the Edinburgh concert, tried it in presence of the writer of this article, and said, "Bellissima—sopra modo bellissima!" Signior Doria attempted to sing along with it, but would not continue, declaring it impossible, because the organ was ill tuned. The truth was, that, on the major key of E♭, the tuning was exceedingly different from what he was accustomed to, and he would not try another key. We mention this particular, to shew how accurately Mr Watt had been able to execute the temperament he intended.

This theory is valuable, therefore, by giving us the management of a phenomenon intimately connected with harmony, and affording us precise and practicable measures of all deviations from it. It bids fair, for this reason, to give us a method of executing any system of temperament which we may find reason to prefer. But we have another ground of estimation of this theory. By its assistance, we are able to ascertain with certainty and precision the true untempered scale of music, which eluded all the attempts of the ingenious Greeks; and we determine it in a way suited to the favourite music of modern times, of which almost all the excellencies and pleasures are derived from harmony. We do not say that this *total* innovation in the principle of musical pleasure is unexceptionable; we rather think it very defective, believing that the thrilling pleasures of music depend more upon the melody or air. We appeal even to instructed musicians, whether the heart and affections are not more affected *(and with much more distinct variety of emotion)* by a fine melody, supported, but not observed, by harmonies judiciously chosen? It appears to us that the effect of harmony, always filled up, is more uniformly the same, and less touching to the soul, than some simple air sung or played by a performer of sensibility and powers of utterance. We do not wonder, then, that the ingenious Greeks deduced all their rules from this department of music, nor at their being so satisfied with the pleasures which it yielded, that they were not solicitous of the additional support of harmony. We see that melody has suffered by the change in every country. There is no Scotchman, Irishman, Pole, or Russian, who does not lament that the skill in composing heart-touching airs is degenerated in his respective nation; and all admire the productions of their muse of "the days that are past." They are "pleasant and mournful to the soul."

43 And accurate methods of temperament.

But we still prefer the harmonical method of forming the scale, on account of its precision and facility: and we prefer the theory of beats, *because it also gives us the most satisfactory scale of melody;* and this, not by repeated corrections and recorrections, but by a direct process. By a table of beats, every note may be fixed at once, and we have no occasion to return to it and try new combinations; for the beatings of the different concords to one bass being once determined, every beating of any one note with any other is also fixed.

44 Fundamental experiment.

We therefore request the reader's patient attention to the experiment which we have now to propose. This experiment is best made with two organ pipes equally voiced, and pitched to the note C in the middle of our harpsichords. Let one of them at least be a stopped pipe, its piston being made extremely accurate, and at the same time easily moved along the pipe. Let the shank of it be divided into 240 equal parts. The advantage of this form of the experiment is, that the sounds can be continued, with perfect uniformity, for any length of time, if the bellows be properly constructed. In default of this apparatus, the experiment may be made with two harpsichord wires in perfect unison, and touched by a wheel rubbed with rosin instead of a bow, in the way the sounds of the vielle or hurdygurdy are produced. This contrivance also will continue the sounds uniformly at pleasure. A scale of 240 parts must

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must be adapted to one string, and numbered from that end of the string where the wheel or bow is applied to it. Great care must be taken that the shifting of the moveable bridge do not alter the strain on the wire. We may even do pretty well with a bow in place of the wheel; but the sound cannot be long held on in any pitch. In describing the phenomena, we shall rather abide by the string, because the numbers of the scale, or length of the sounding part of the wire, correspond, in fact, much more exactly with the sounds. The deviations of the scale of the pipe do not in the least affect the conclusions we mean to draw, but would require to be mentioned in every instance, which would greatly complicate the process.

Having brought the two open strings into perfect unison, so that no beating whatever is observed in the consonance, slide the moveable bridge slowly along the string while the wheel is turning, beginning the motion from the end most remote from the bow. All the notes of the octave, and all kinds of concords and discords, will be heard; each of the concords being preceded and followed by a ruffling beating, and that succeeded by a grating discord. After this general view of the whole, let the particular harmonious stations of the bridge be more carefully examined as follows.

45 Determination of the octave, and character of concord.

I. Shift the moveable bridge to the division 120. If it has been exactly placed, we shall hear a perfect octave without any beating. It is, however, seldom so exactly set, and we generally hear some beating. By gently shifting the bridge to either side, this beating becomes more or less rapid; and when we have found in which direction the bridge must be moved, we can then slide it along till the beating cease entirely, and the sounds coalesce into one sound. We can scarcely hear the treble or octave note as distinguishable from the bass or fundamental afforded by the other string. If the notes are duly proportioned in loudness, we cannot hear the two as distinct sounds, but a note seemingly the same with the fundamental, only more brilliant. (*N B.* It would be a great improvement of the apparatus to have a micrometer screw for producing those small motions of the bridge.)

Having thus produced a fine octave, we can now perceive that, as we continue to shift the bridge from its proper place, in either direction, the beating becomes more and more rapid, changes to a violent rattling flutter, and then degenerates into a most disagreeable jar. This phenomenon is observed in the deviation of every concord whatever from perfect harmony, and must be carefully kept in remembrance.

46 Harmony more strict than melody.

Before we quit this concord, the octave, produced by the bisection of the pipe or string, we must observe, that, with respect to ourselves, the octave $c\bar{c}$ must beat almost twice in a second, before we can observe clearly any mis-tune in it, by sounding the notes in succession, or as steps in the scale of melody. We never knew any ear so nice as to discover a mis-tuning when it beats but once in three seconds. We think ourselves intitled therefore to say, that we are insensible of a temperament in melody amounting to one third of a comma; and we never knew a person sensible of a temperament half this bulk.

When the imperfection of the octave is clearly sensible by sounding the notes in succession, it is extremely disagreeable, feeling like a struggle or endeavour to attain a certain note, and a failure in the attempt. This seems owing to the familiar similarity of octaves, in the habitual talking and singing of men and women together. But when the notes are sounded together, although we are not much more sensible of the imperfection of the harmony directly, as a failure in the sweetness of the concord, we are very sensible of this phenomenon of beating; and any person who can distinguish a weak sound from a stronger one, can easily perceive, in this indirect manner, any fraction of a comma, however minute. This makes the tuning by harmony much more exact than by melody alone. It is also much more accommodated to the genius of modern music. The ancients had favourite passages, which were frequently introduced into their airs, and they were solicitous to have these in good tune. It appears from passages in the writings of Galen, that different performers excelled chiefly in their skill in making those occasional temperaments which their music required. Our music is much more strict, by reason of our harmonic accompanyments, which are an abominable noise when mis-tuned in a degree, which would have passed with the ancients for very good melody. Aristoxenus says, that the ear cannot discover the error of a comma. This would now be intolerable.

47 It gives the best scale for melody.

But another advantage attends our method. We obtain, by its assistance, the most perfect scale of melody; perfect in a degree attainable only by chance by the Greeks. This is now to be our business to unfold.

48 Determination of the 5th.

II. Set the moveable bridge at 158, and sound the two strings. They will beat very disagreeably, being plainly out of tune. Slide it gradually toward 160, and the beats will grow slower and slower; will change to a gentle and not unpleasant undulation; and at last, when the bridge is at 160, will vanish entirely, and the two sounds will coalesce into one sweet concord, in which neither of the component sounds can be distinguished. If the sound given by the short string be now examined as a step in the scale of melody, it will be found a fifth to the sound of the long string or fundamental note, perfectly satisfactory to the nicest ear. Thus one step of the scale has been ascertained.

III. Slide the bridge slowly along the string. The beating will recommence, will become a flutter, and then a jarring noise; and will again change to an angry flutter, beating about eight times in a second, when the bridge stands at 169 nearly. Pushing it still on, but very slowly, the flutter will become an indistinct jarring noise; which, by continuing the motion, will again become a flutter, or beat about six in the second. The bridge is now about 171.

49 Determination of the 4th.

IV Still continuing the motion, the flutter becomes a jarring noise, which continues till the bridge is near to 180, when the rapid flutter will again be heard. This will become slower and slower as we approach to 180; and when the bridge reaches that point, all beating vanishes, and we have a soft and agreeable concord, but far inferior to the former concord in that cheering sweetness which characterises the fifth. When this note is compared with that of the fundamental string as a step in the scale of melody, it is found to correspond to the note *fa*, or the fourth step in the scale, and in that employment to give complete satisfaction to the ear.

V. Still advancing the moveable bridge toward the

Temperament of the Scale of Music. nut, we shall hear the beatings return again; and after fluttering and degenerating to a jarring noise, by a very small motion of the bridge, they will again be heard, will grow slower, accompanied with a sort of angry expression, and will cease entirely when the bridge reaches

50 Determination of the IIId. the 192d division of our scale. Here we have another concord of very peculiar character, being remarkably enlivening and gay. This sound gives perfect satisfaction to the ear, if employed as the third step in the scale of melody, being the note *mi* of that series, at least in all gay or cheerful airs.

51. VI. As we move the bridge from 192 to 200, we hear again the same beatings, which, in the immediate vicinity to 192, have a peevish fretful expression, instead of the angry waspish expression before mentioned. When the bridge has passed that situation which produces only grating discordance, we hear the beatings again, and they become slower, and cease altogether when the bridge arrives at 200. Here we have another consonance, which must be called a *concord*, because it is rather agreeable than otherwise, but strongly marked by a mournful melancholy in the expression. In the scale of melody, it forms the third step in those airs which express lamentation or grief. It is called the *minor third*, to distinguish it from the last enlivening concord, which, being a larger interval, is called the *major third*.

52 Determination of the 3d. It is well known, that these two thirds give the distinguishing characters to the only two modes of melodious composition that are admitted into modern music. The series containing the major third is called the *major*, and that containing the minor third is called the *minor mode*. It is worthy of remark, that the fanatical preachers, in their conventicles and field sermons, affect this mode in their harangues, which are often distinctly musical, modulating entirely by musical intervals, and keeping the whole of their chaunt in subordination to a fundamental or key note. This is not unnatural, when we consider the general scope of their discourses, namely, to inspire melancholy and humiliating thoughts, awakening sorrow, and the like. It is not so easy to account for the usual whine of a beggar, who generally craves charity in the major third. This is the case, at least, in the northern parts of this island.

53. If we continue to shift the bridge still nearer to the end of the string, we shall hear nothing but a succession of vile discordant noises, somewhat less offensive when the bridge is about the divisions 213 and 216, but even there very unpleasant.

54 Determination of the 6th. VII. Let us therefore change our manner of proceeding a little, and again place the bridge at 160, which will give us the pleasing concord of the fifth. Instead of pushing it from that place toward the nut, let it be moved toward the wheel or bow. Without repeating what we have said of the reappearance of the beatings, their acceleration, and their degenerating into a jarring discord, to be afterwards succeeded by another beating, &c. &c. we shall only observe, that when we place the bridge at 150, we have no beatings, and we hear a consonance, which is in a slight degree pleasant, and may therefore be called a *concord*. It has the other marks of a concord which we have been making so much use of; for the beatings recommence when we shift the bridge to either side of 150. This note makes the sixth step in the descending scale of mournful melody; that is, when we are passing from the acute to the graver notes, with the intention of putting an emphasis on the third and the fundamental. Although not eminent as a concord with the fundamental alone, it has a most pleasing effect when listened to in subordination to the whole series, or when sounded along with other proper accompanyments of the fundamental.

VIII. Placing the bridge at 144, we obtain another very pleasing concord, differing in its expression from any of the foregoing. We find it difficult to express its character. It is greatly inferior to the fifth in sweetness, and to the major third in gaiety, but seems to possess, in a lower degree, both of those qualities. In the scale of cheerful melody, it is the sixth note, which we have distinguished by the syllable *la*. It is also used even in mournful melody, when we are ascending, with the intention of closing with the octave. 55 Determination of the VIth.

In shifting the bridge from 144 to 120, we obtain nothing but discordant, or at least disagreeable consonances. And, lastly, if we move the bridge beyond 120, to divisions which are respectively the halves of those numbers which produced the concords already treated of, we obtain the same steps in the scale of the upper octave. Thus if the bridge be at 80, we have the fifth to the octave note, or twelfth to the fundamental. If it be at 60, we obtain the double octave, &c. &c. &c. 56 Scale of the upper octave.

We have perhaps been rash in affixing certain moral or sentimental characters to certain concords; for we have seen instances of persons who gave them different denominations; but these were never contradictory to ours, but always expressed some sentiment allied to that which we have assigned. We never met with an instance of a person capable of a little discriminating reflection, who did not acknowledge a manifest sentimental distinction among the different concords which could not be confounded. We doubt not but that the Greeks, a people of exquisite sensibility to all the beauties of taste and sentiment, paid much attention to these characters, and availed themselves of them in their compositions. We do not think it at all unlikely, that greater effects have been produced by their music, which was studied with this express view, than have ever been produced by the modern music, with all the addition of harmony. We have allowed too great a share of our attention to mere harmony. Our great authors are much less solicitous to compose an enchanting air, than to construct a full score of rich and well conducted harmony. We do not profess to be nice judges in musical composition, but we may tell what we ourselves experience. We find our minds worked up by a continuance of fine harmony into a *general* sensibility; into a frame of mind which would prepare and fit us for receiving strong impressions of moral sentiment, if these were distinctly made. But we have seldom felt any distinct emotions excited by mere instrumental music. And when the harmonies have been merely to support the performance of a voice, the words have been either so frittered by musical divisions, as to become in some measure ludicrous—or have been so indistinct, and made so trifling a part of the music, that there was nothing done to give a particular shape to the moral impression on our mind. We have generally been strongly affected by some of the anthems which were in vogue in former times; and we think that we perceived the cause of 57 Characters of the different concords.

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of this difference. There was a great simplicity in the voice parts: the syllables were not drawled out into long musical phrases, but pronounced nearly according to their proper quantities; so that the sentiment of the speaker was expressed with all the force of good declamation, and the harmony of the accompanyment then strengthened the appropriate effect of the melody. We mean not to offer these observations as of much authority, but merely to mention some facts, and to assign what we felt to be their causes, in order to promote, in some degree, however insignificant, the cultivation of musical science. With this view, we venture to say, that some of the best compositions of Knapp of York *uniformly* affect us more than the more admired anthems of Bird and Tallis. A cadence, which Knapp gives almost entirely to the melody, is laboured by Bird or Tallis with all the rules of art; and you have its characters of perfect or imperfect, full or disappointed, cadences, and such an apparatus of preparation and resolution of discords, that you foresee it at the distance of several bars, and then the part assigned to the voice seems a very trifle, and merely to fill up a blank in the harmony. Such compositions smell of the lamp, and fail of their purpose, that of charming the *learned* ear. But enough of this digression.

58. Thus have we found a natural relation between certain sounds strongly marked by very precise characters. The concordance of sound is marked by the absence of all undulation, and the deviations from this harmony are shewn to be measurable by the frequency of those undulations. We have also found, that the notes, which are thus harmonious along with the fundamental, are steps in the scale of natural music (for we must acknowledge melody to be the primitive music, dictated by nature). We have got the notes *do—mi*, *fa*, *sol*, *la—do*, ascertained in a way that can no longer be mistaken.

59. Relations belonging to the concords, &c.

Let us now examine what physical or mechanical relations these sounds stand into each other. Our monochord gives us the lengths of the strings; and the discovery of Galileo shews us, that these are also the durations of the aëreal pulses which produce the sensations of musical notes. Their ratios may therefore be truly called the ratios of the sounds. Now we see that the strings which produce the sounds *do sol* are 240 and 160. These are in the ratio of 3 to 2. In this manner we may state all the ratios observed in our experiment, *viz.*

Do : *mi* have the ratio of	240 to 192, or of	5 to 4
Do : *fa*	240 : 180	4 : 3
Do : *sol*	240 : 160	3 : 2
Do : *la*	240 : 144	5 : 3
Mi : *sol*	192 : 160	6 : 5, = *do* : *mi*^{b}
Fa : *sol*	180 : 160	9 : 8
Sol : *la*	160 : 144	10 : 9
Mi : *fa*	192 : 180	16 : 15

Here we get the sight of all the ratios which the ingenious and unwearied speculations of the Greek mathematicians enlisted into the service of music, without being able to give a good reason why. The ratio 5 : 4, which their fastidious metaphysicians rejected, and which others wished to introduce from motives of mere necessity to fill up a blank, is pointed out to us by one of the finest concords. The interval between the fourth and the fifth is, *very fortunately*, a step of the scale.

The next step *sol la* is more important. For the ear for melody would have been very well satisfied with an interval equal to *fa sol*, or 9 : 8; but if the moveable bridge be set at the division $142\frac{2}{9}$, corresponding to such a step, we should have a very offensive fluttering. It is reasonable therefore to conclude, *from analogy*, that the interval *sol la* does not correspond to the ratio 9 : 8; and that 10 : 9, which is, at least, equally satisfactory to the ear, is the proper step, even in the scale of melody. If we consider what may be called the scale of harmony, there is no room left for doubt. To enjoy the greatest possible pleasure of harmony, we must not only take each note as it is related to the fundamental, but also as it is related to other notes of the scale. It may chance to be convenient to assume, for the fundamental of our occasional scale of modulation, the string of the lyre which is tuned as *fa* to its proper fundamental; or it may increase the harmony (and we know that it does) if we accompany the note *do* with both of the notes *fa* and *la*. To have the fine concord of the major third, it is necessary that the interval *fa la* be equivalent to the ratio 5 : 4. Now *fa* is 180, and 5 : 4 = 180 : 144. Therefore, by making the step *sol la* equal to 9 : 8, we should lose this agreeable concord, and get discord in its place.

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60. Observations on the step *sol la*.

And thus is evinced, in opposition to Aristoxenus, the propriety of having both a major and a minor tone; the first expressed by 9 : 8, and the last by 10 : 9. The difference between these steps is the ratio 81 : 80, called a comma by the Greek theorists.

61. Determination of the VIIth.

We still want two steps of the scale, and two sounds or notes corresponding to them, namely *re* and *si*; and we wish to establish them on the same authority with the rest. We see that this cannot be done by a concordance with the fundamental *do*. The ear sufficiently informs us that the steps *do re* and *la si* must be tones, and not semitones, like *mi fa*. The sensible similarity of the two tetrachords *do re mi fa* and *sol la si do*, also teaches us that the step *si do* should be a semitone like *mi fa*. This seems to be all that mere melody can teach us. But we have little information whether we shall make *la si* a major or a minor tone. If we copy the tetrachord *do re mi fa* exactly, we shall make the step *si do* like *mi fa*, and equivalent to the ratio 16 : 15. This requires the moveable bridge to be placed at 128. The sound produced by this division is perfectly satisfactory to the ear as a step of the scale of melody. Moreover, our satisfaction is not confined to the comparison of it with the note *do*, into which we slide by this gentle step. It makes agreeable melody when used as the third to the note *sol*. If we examine it mathematically, we find it a perfect major third to *sol*; for *sol* requires the 160th division. Now 160 : 128 = 5 : 4, which is the ratio of the pulses of a major third. All these reasons seem enough to make us adopt this determination of the note *si*.

62. Determination of the IId.

It remains to consider how we shall divide the interval *do—mi*. It is a perfect major third. So is *fa la*, and so is *sol si*. But in the first of these two, we have seen that it must be composed of a major tone with a minor tone above it; and in the second we have a minor tone followed by a major tone above. We are left uncertain therefore whether *do re* shall resemble *fa la* or *sol si* in the position of its two parts. Aristoxenus and his followers declared the ear to be equally pleased with both. Ptolemy's *Systema Diatonicum Intensum* makes *do re* a major tone, and other systems make it a minor. E-

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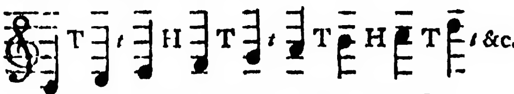
ven in modern times it has been considered as uncertain; and the only reason which we have to offer for a preference of the major tone for the first step is, that, so far as we can judge by our own feelings, the sounds in the relation of 9 : 8 are less discordant than sounds in the relation of 10 : 9, and because all the other steps have been determined by means of concords with the key. We refer, for a more particular examination of the principles on which these arrangements are valued, to *Dr Smith's Harmonics*, Prop. I. where he shews how one is preferable to another, in proportion as it affords a greater number of perfect concords among the neighbouring notes, which is the favourite object in all modern music. Upon this principle our arrangement is by far the best, because it admits five more concords in the octave than the other. But we have considered the subject in a different manner, merely to avail ourselves of the phenomenon by which all the steps, except one, seem to be naturally ascertained, and by which the connection between harmony and melody seems to be pointed out to us.

63.

It will be convenient to represent the tones major and minor and the hemitone, by the symbols T, *t*, and H. Also to mark the notes by the Roman numerals, or by cyphers, according as they are the extremes of major or minor intervals. By this notation the octave may be represented thus:

C D E F G A B *c* *d* *e*



$\frac{8}{9}$ $\frac{9}{10}$ $\frac{15}{16}$ $\frac{8}{9}$ $\frac{9}{10}$ $\frac{8}{9}$ $\frac{15}{16}$ $\frac{8}{9}$ &c.

K II III 4 V VI VII VIII IX X &c.

The reader will remark, that the primary divisions which we assigned to the representation of an octave in fig. 1. by the circumference of a circle, are in conformity to this Ptolemaic partition of the octave. He will also be sensible, that the division into five equal mean tones and two equal hemitones, which is expressed by the dotted lines, agreeing with the Ptolemaic division only at C and E, is effected by bisecting the arch CE; and therefore the deviation of the sound substituted for the Ptolemaic D is half the difference of CD and DE, that is, half a comma. The deviations therefore at F, G, A, and B, are each a quarter of a comma.

Logarithmic measure of the musical intervals.

It is well known, that if the logarithm of the length of one string be subtracted from that of another, the difference is a measure of the ratio between them. Therefore 30103 is the measure of the musical interval called the octave, and then the measures of the

Comma	540 or	54
Hemitone	2803	280
Minor tone	4576	458
Major tone	5115	512
3d	7918	792
IIId	9691	969
4th	12494	1249
Vth	17609	1761
6th	20412	2041
VIth	22185	2219
VIIth	27300	2730
VIIIth	30103	3010

This is a very convenient circumstance. If we take only the four first figures as integers, and make the octave consist of 3010 parts, we have a scale more exact than the nicest harmony requires. The circumference of a circle may be so divided into 301 degrees, and the moveable circle have a nonius, subdividing each into 10. Or it may be divided into 55,8 degrees, each of which will be a comma. Either of these divisions will make it a most convenient instrument for expeditiously examining all temperaments of the scale that can be proposed. Or a straight line may be so divided, and repeated thrice. Then a sliding ruler, divided in the same manner, and applied to it, will answer the same purpose. We shall see many useful employments of these instruments by and by.

Having thus endeavoured to communicate some plain notion of the formation and singular nature of that gradation of sounds which produces all the pleasures of music, and of the manner of obtaining the steps of this gradation with certainty and precision, we proceed to consider how those musical passages may be performed on such keyed instruments as the organs and harpsichords, as they are now constructed. These instruments have twelve sounds and intervals in every octave, in order that an air may be performed in any pitch; that is, taking any one of the sounds as a key note. It is plain that this cannot be done with accuracy; for we have now seen that the interval *mi fa* is bigger than half of *do re* or *re mi*, &c. and therefore the intercalary sound formerly mentioned to be inserted between C and D, D and E, &c. will not do indiscriminately for the sharp of the sound below and the flat of the sound above it. When the tones are reduced to a mean size, the ear is scarcely sensible of the change in melody, and the harmony of the fifths and fourths is not greatly hurt. But when the half notes are inserted, and employed to make up harmonious intervals, as recommended by Zarlino, the harmony is very coarse indeed.

65 Why temperament necessary.

But we must make the reader sensible of the necessity of some temperament, even independent of those artificial notes. Therefore

Let the scholar tune upwards the four Vths $c\,g$, $g\,\bar{d}$, $\bar{d}\,\bar{a}$, $\bar{a}\,\bar{\bar{e}}$, all perfect, admitting no beating whatever. This is easily done, either with the organ or the wheel monochord already described. Then tune downwards the perfect octaves $\bar{\bar{e}}\,\bar{e}$, $\bar{e}\,e$. Now examine the IIId $c\,e$ which results from this process. If the instrument be of the pitch hitherto supposed (c making 240 pulses in a second), this IIId will be heard beating 15 times in a second, which is a discordance altogether intolerable, the note e being too sharp in the ratio of 81 to 80, which makes a comma. It is easily found, by calculation, that e makes $303\frac{3}{4}$ pulses, instead of 300, required for the IIId to c.

N. B. It may not be amiss to inform our readers, that if any concord, whose perfect ratio is $\frac{m}{n}$ (m being the greatest term of the smallest integers expressing that ratio), be tempered sharp by the fraction $\frac{p}{q}$ of a comma, and if M and N be the pulses made by the acute and grave notes of the concord during any number of seconds, the number b of beats made in the same time by this concord will be $= \frac{2\,q\,m\,N}{161\,p-q}$, or $\frac{2\,q\,n\,M}{161\,p+q}$;

and

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and if it be tempered flat, then $b = \frac{2qmN}{161\overline{p+q}}$, or $\frac{2qnM}{161\overline{p+q}}$ (*Smith's Harm.* 2d edit. p. 82, &c.)

66. It is impossible, therefore, to have perfect Vths and perfect IIIds at the same time. And it will be found, that the 3d $e\,g$ resulting from this process, and the VIth $c\,\overline{a}$, are still more discordant, rattling at an intolerable rate. Now the major and minor thirds, alternately succeeding each other, form the greatest part of our harmonies; and the VIth is also a very frequent accompanyment. It is necessary therefore to sacrifice somewhat of the perfect harmony of the Vths, in order that we may not be disgusted with the discord of those other harmonies: and it is this mutual accommodation, and not the changes made necessary by the introduction of intercalary notes, which is properly called TEMPERAMENT. It will greatly assist us in understanding the effects of the temperaments of the different concords, if we examine all the divisions of the circular representation of the octave and musical scale given in fig. 1. by placing the index of the moveable circle on that note of the outer circle for which we want the proper harmonics, or accompanyments, which are either the IIId and Vth, or the 4th and VIth. We shall thus learn, in the *first* place, the deviations of the different perfect notes of the scale from the notes required for this new fundamental; and we must then study what effect the same temperament produces on the agreeableness of the harmony of different concords having the same bass or the same treble, taking it for granted that the hurt to the harmony of any individual concord is proportional to its temperament.

67 How this may be obtained by the beats.

It is in this delicate department of musical science that we think the great merit of Dr Smith's work consists. We see that the deviation from perfect harmony is always accompanied with beats, and increases when they increase in frequency—whether it increases in the same proportion may be a question. We think that Dr Smith's determination of the equality of imperfect harmony in his 13th proposition includes every mathematical or physical circumstance that appears to have any concern in it. What relates immediately to our sensations is, as yet, an impenetrable secret. The theory of beats, as delivered by this author, affords very easy, though sometimes tedious, methods of measuring and of ensuring all the varieties which can obtain in the beating of imperfect consonances. It appears to us therefore very unjust to say, with the late writer in the Philosophical Transactions, that this obscure volume has left the matter where it found it. The author has given us *effective* principles, although he may have been mistaken in the application; which however we are far from affirming. Our limits will not allow us to give any account of that theory; and indeed our chief aim in the present article is to give a method of temperament which requires no scientific knowledge of the subject. But we could not think of losing the opportunity of communicating, by the way, to unlearned persons, some more distinct notions of the scale of musical sounds, and of its foundation in nature, than scholars usually receive from the greater number of mere music masters. The acknowledged connection of the musical ratios with the pleasures of harmony and melody, has (we hope) been employed in an easy and not obscure manner; and the phenomena which we have faithfully narrated shew plainly that, by diminishing the rattling undulations of tempered concords, we are certain of improving the harmony of our instruments. We shall proceed therefore on this principle for the use of the mere performer, but at the same time introducing some very simple deductions from Smith's theory, for which we expect the thanks of all such readers as wish to see a little of the reasons on which they are to proceed.

68 Method in practice.

The experiment, of which we have just now given an account, shews that four consecutive fifths compose a greater interval than two octaves and a major third. Yet, in the construction of our musical instruments of fixed sounds, they must be considered as of equal extent; since we have 7 half intervals in the Vth, and 12 in the octave, and four in the IIId, four Vths contain 28, and two octaves contain 24; and these, with the four which compose a IIId, make also 28. It is plain, therefore, that whatever we do with the IIIds, we must lessen the Vths. If therefore we keep the IIId perfect, we must lessen each of the Vths by $\frac{1}{4}$th of a comma; for we learned, by the beating of the imperfect IIId $c\,e$, that the whole excess of the four Vths was a comma. Therefore the Vth $c\,g$ must be flattened $\frac{1}{4}$th of a comma. But how is this to be done with accuracy? Recollect the formula given a little ago, where the number of beats b in any number of seconds is $= \frac{2qmN}{161 \times \overline{p+q}}$. In the present case $q = 1$, $m = 3$, $N = 240$ per second, and $p = 4$. Therefore the formula is $= \frac{2 \times 3 \times 240}{161 \times \overline{4+1}} = \frac{1440}{645} = 2{,}25$ in a second, or 9 beats in four seconds very nearly.

In like manner, the next Vth $g\,\overline{d}$ must be flattened $\frac{1}{4}$th of a comma, by making it beat half as fast again, or $13\frac{1}{2}$ beats in four seconds (because in this Vth $N = 360$). But as this beating is rather too quick to be easily counted, it will be better to tune downwards the perfect octave g G, which will reduce N to 180 for the Vth G d. This will give us 1,68 per second, or 10 beats in 6 seconds very nearly.

There is another way of avoiding the employment of too quick beats. Instead of tuning the octave g G, make c G beat as often as $c\,g$. This is even more exactly an octave to g than can be estimated by a good ear. Dr Smith has demonstrated, that when a note makes a minor concord with another note below it, and therefore a major concord with the octave to that note, it beats equally with both; but if the major concord be below, it beats twice as fast with the octave above. Now, in the present case, $c\,g$ is a Vth, and c G a 4th. For the same reason $c\,f$ would beat twice as fast as c F.

In the next place, the Vth $\overline{d}\,\overline{a}$ must be made to beat flat 15 times in 6 seconds.

In like manner, instead of tuning upward the Vth $\overline{a}\,\overline{e}$, tune downward the octave $\overline{a}\,a$, and then tune upward the Vth $a\,e$, and flatten it till it beat 15 times in 8 seconds.

If we take 15 seconds for the common period of all these beats, we shall have

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The beats of $cg = 34$.
$Gd = 25$.
$da = 37\frac{1}{2}$.
$ae = 28$.

69. We shall now find ce to be a fine IIId, without any sensible beating; and then we proceed in the same way, always tuning upward a perfect Vth; and when this would lead us too high, and therefore produce too quick beating, we should tune downward an octave. Do this till we reach b ✗, which should be the same with $\bar{c}$, or a perfect octave above c. This will be a full proof of our accurate performance. But the best process of tuning is to stop when we get to g ✗. Then we tune Vths downward from c, and octaves upward when the Vths would lead us too low. Thus we get c F, Ff, $f b^b$, $b^b \bar{b}^b$, $\bar{b}^b e^b$, and thus complete the tuning of an octave. We take this method, instead of proceeding upwards to b ✗; because those notes marked sharp or flat are, when tuned in this way, in the best relation to those with which they are most frequently used as IIIds.

70 Use of a variable pendulum. This process of temperament will be greatly expedited by employing a little pendulum, made of a ball of about two ounces weight, sliding on a light deal rod, having at one end a pin hole through it. To prepare this rod, hang it up on a pin stuck into the wainscoting, and slide the ball downward, till it makes 20 vibrations in 15″, by comparing it with a house clock. In this condition mark the rod at the upper edge of the ball. In like manner, adjust it for 24, 28, 32, 36, 40, 44, 48, vibrations, making marks for each, and dividing the spaces between them by the eye, noticing their gradual diminution. Then, having calculated the beats of the different Vths, set the ball at the mark suited to the particular concord, and temper the sound till the beats keep pace exactly with the pendulum.

71 Absolute number of pulses how known. But, previous to all this, we must know the number of pulses made in a second by the C of our instrument. For this purpose we must learn the pulses of our tuning fork. To learn this, a harpsichord wire must be stretched by a weight till it be unison or octave below our fork: then, by adding $\frac{1}{40}$th of the weight to what is now appended, it will be tempered by a comma, and will beat, when it is sounded along with the fork; and we must multiply the beats by 80: The product is the number of pulses required. And hence we calculate the pulses of the C of our instrument when it is tuned in perfect concord with the fork.

The usual concert pitch and the tuning forks are so nearly consonant to 240 pulses for C, that this process is scarcely necessary, a quarter of a tone never occasioning the change of an entire beat in any of our numbers.

72 System of temperament with perfect IIId. The intelligent reader cannot but observe, that this system of tuning with perfect IIIds, which is preferred to all others by many great masters, is the one represented by our circular figure of the octave. The IIId is there perfect, and the Vth CG is deficient by a quarter of a comma. We cannot here omit taking notice of a most valuable observation of Dr Smith's on this temperament, and, in general, on any division of the octave into mean tones and equal limmas.

73 Proportional variation of temperament. The octave being made up of five mean tones and two limmas, it is plain that, by enlarging the tones, we diminish the limmas, and that the increment of the tone is two fifths of the contemporaneous diminution of the limma. If, therefore, we employ the symbol v to express any minute variation of this temperament, and make the increment of a mean tone $= 2v$, the contemporaneous variation which this induces on a limma $= -5v$; and if the tone be diminished by the same quantity $-2v$, the limma will increase by the quantity $5v$. Let us see what are the contemporaneous changes made on all the intervals of the octave when the tone is diminished by $2v$.

1. A Vth is made up of three tones and a limma. Therefore the variation of its temperament is $= -6v + 5v$, or is $= -v$. That is, the Vth is flattened from its former temperament, whatever that may have been, by the quantity $-v$. Consequently the 4th, which is always the complement of the Vth to the octave, has its temperament sharpened by the quantity v.

2. A IId, being a tone distant from the fundamental, has its temperament changed by $-2v$.
Therefore a minor 7th is raised by $2v$.

3. A minor 3d is made up of a tone and a limma: therefore its variation is $= -2v + 5v$, or $= 3v$.
Therefore a major VIth (its complement) loses $-3v$.

4. A maj. IIId, or two tones, has its variation $= -4v$.
Therefore a minor 6th has its variation $= 4v$.

5. A maj. VIIth, the complement of a limma has $-5v$.

6. A tritone, or IVth, must have the variation $= -6v$.
Therefore the false 5th must have . . . $6v$.

74 Geometrical construction founded on this. From this observation, Dr Smith deduces the following simple mathematical construction: In the strait line CE (fig. 2.) take the six equal parts Cg, $g\,d$, $d\,a$, a E, E b, $b\,t$, and draw through the points of division the six parallel lines g G, dD, &c. Let these lines represent so many scales of the octave, so placed that the points C, g, d, &c. may represent the points C, g, d, &c. of the circular scale in fig. 1. where it is cut by the dotted lines representing the system of mean tones and limmas. Then, *1st*, take a certain length dG on the first line, to the right hand of the line CE, to represent a quarter of a comma, G will mark the place of the perfect Vth, while g represents that of the mean or tempered Vth. *2dly*, Set off dD, double of g G, in like manner, to the right hand on the second parallel. This will be the place of the perfect IId to the key note C. *3dly*, Also set off a A, on the third parallel, to the left hand, equal to g G. This will mark the place of A, the VIth to the key note C. *4thly*, Place E on the point e, because, in the system of mean tones represented in fig. 1. the IIIds were kept perfect. *5thly*, Make b B, to the right hand on the fifth line, equal to g G, to mark the place of the perfect VIIth to the key note C. And, *6thly*, make t T, to the right hand on the sixth line, equal to twice g G. This will serve for shewing the contemporaneous temperament of the tritone, or IVth, contained between F and B, as also of its complement, the false 5th in fig. 1.

It is evident that the temperament of all the notes of the octave, according to the above-mentioned system, are properly represented in this figure. The Vth is tempered flat by the quarter comma Gg; the IId is tempered flat by the half comma Dd; the VIth is tempered sharp by a quarter comma Aa; the IIId is perfect; the VIIth is flat by a quarter comma Bb; and the 4th is sharp by a quarter comma Gg.

75 The temperer. Now, let any other straight line C t' be drawn from C across these parallels. This will mark, by the intervals

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vals g' G, d' D, &c. the temperaments of another syſtem of mean tones and limmas. For it is evident, that the contemporaneous variations gg', dd', &c. from the former temperament, are in the juſt proportions to each other; gg' being $= - v$, the variation proper for the Vth, and the oppoſite temperament for its complement or 4th. In like manner, aa' is $= 3v$, the variation competent to the VIth; and E e' is $= 4v$, the proper variation for the IIId.

In like manner, bb' is $= 5v$, the variation of the VIIth and 2d. And, laſtly, tt' is the variation $6v$ of the tritone, and its complement, the falſe fifth.

For all theſe reaſons, any ſtraight line C e' or C e'', drawn from C acroſs the parallels, may juſtly be called the TEMPERER.

76 This is a very uſeful conſtruction: For it is plain, that the ſounds which can be placed in our organs and harpſichords, which have only twelve keys for an octave, muſt approach to a ſyſtem of mean tones. The diviſion of the octave into twelve equal intervals is ſuch a ſyſtem of mean tones exactly. Now, in ſuch ſyſtems, when a line is drawn from C acroſs the parallels, we ſee, at one glance, not only all the temperaments of the notes with the key note, but alſo the temperaments of thoſe concords which the notes employed in full harmony make with each other. Thus, in the harmony of K — III — V, the III and V make a minor 3d with each other; and in the harmony of K — 4 — VI, the 4 and VI make a major 3d with each other. Now the reader will eaſily ſee, that the firſt of theſe concords has its interval diminiſhed on both ſides, when the III is tempered ſharp, but only on one ſide when it is tempered flat. The mathematical reader will alſo eaſily ſee, that the contemporaneous temperament A a' of the VIth is always equal to the ſum g' G and E e', and that A a'' is equal to the difference of g'' G and E e''. Therefore the temperament of this ſubordinate concord, in the full harmony K — III — V, is, in all caſes, the ſame with the contemporaneous temperament of the VIth.

In like manner, he will perceive that the temperament of the ſubordinate IIId, in the harmony of K — 4 — VI, is equal to the contemporaneous temperament of the III.

We alſo ſee, in general, that the whole harmony is more hurt when the temperer lies in the angle ECK, with the IIId tempered ſharp, than when it is in the angle ACE, when the IIId is flat; and that the ſum of all the temperaments of the concords with the key is the ſmalleſt when the IIIds are perfect. This ſyſtem of mean tones, with perfect IIIds, would therefore be the beſt, if the harmony of different concords were equally hurt by the ſame temperament.

...ce of ...eat uſe.

We do not know any thing that has been publiſhed on the ſcience of muſic that gives more general and ſpeedy inſtruction than this ſimple figure. If it be drawn of ſuch a ſize as to allow the comma EK to be divided into a number of equal parts, ſufficiently ſenſible, all trouble of calculation will be ſaved.

We would therefore propoſe to accompany this figure with proper ſcales.

The *firſt* ſcale ſhould have G g divided into $13\frac{1}{2}$ parts. This will expreſs the logarithmic meaſures of the temperaments mentioned in n° 63. a comma being $= 54$.

The *ſecond* ſcale ſhould have g G divided into 36 parts. This gives the beats made in 16 ſeconds by the notes c, g, when tempered by any quantity G g'.

The *third* ſcale ſhould have g G divided into 60 parts, for the beats made by the notes c, e, or the notes c, $\bar{a}$.

The *fourth* ſcale ſhould have g G divided into 72 parts. This gives the beats made by the key note C, with its minor third e^b.

The *fifth* ſcale ſhould have g G divided into 48 parts, for the beats made by the notes c, f.

The *ſixth* ſcale ſhould have g G divided into 89 parts, on which A a' is meaſured, to get the beats of the ſubordinate concord formed by g and e in the harmony of K — III — V.

And, *laſtly*, g G, divided into 80 parts, will give the beats made by f and $\bar{a}$ in the harmony of K — 4 — VI.

78 Harmonioufneſs, what?

We are ignorant of the immediate efficient cauſes of the pleaſure we receive from certain conſonances, and ſhould therefore receive, with ſatisfaction, any thing that can help us to approximate to a meaſure of its degrees. We know that, in fact, the pleaſantneſs of any individual concord increaſes as the undulations called *beats* diminiſh in frequency. It is probable that we ſhall not deviate very far from the truth, if we ſuppoſe the harmonioufneſs of an individual tempered concord to be proportional to the ſlowneſs of theſe undulations. But it by no means follows, that a tempered Vth and a IIId are equably pleaſant, each in its kind, when they beat equally ſlow. There is a difference *in kind* in the pleaſures of theſe concords: and this muſt ariſe from the peculiar manner in which the component pulſes of each concord divide each other. We are certain that this is all the difference that obtains between them in Nature. But the harmonioufneſs here ſpoken of is the arrangement which produces this pleaſure. We are intitled to ſay, that this is equal in two given inſtances, when the arrangements are preciſely ſimilar; and when the things arranged are the ſame, nothing ſeems to remain in which the inſtances can differ.

At any rate, it is of conſequence to be able to proportion and diſtribute theſe undulations at pleaſure. They are unpleaſant; and when reinforced by uniting, muſt be more ſo. The theory puts it in our power to prevent this union: perhaps by making them very unequal; or, if this ſhould give a chance of periodic accumulation, we may find it better to make them all equal. Surely to have all this in our power is very deſirable; and this is obtained by the theory of the beats of imperfect conſonances.

79 Temperament of a whole octave by beats.

But we are forgetting the proceſs of tuning, and have only tuned three or four notes of our octave. We muſt tune the reſt by conſidering their relation to notes already tuned. Thus, if $g\,c$ makes 36 beats in 16 ſeconds, F c ſhould make one third leſs, or about 24 in the ſame time; becauſe N in the formula is now 160 inſtead of 240. Proceeding in this way, we ſhall tune the octave C c moſt accurately as a ſyſtem of mean tones with perfect IIIds, by making the notes beat as follows. A point is put over the note that is to be tuned from the other, and a +, or a --, means that the concord is to be tempered ſharp or flat. Thus g is tuned from c,

Make	$c\,\dot{g}$ beat	—	36 times in 16 ſeconds
	$\dot{G}\,c$	+	36
	$G\,\dot{d}$	—	27, *i. e.* $\frac{3}{4}$ths of $\dot{g}\,c$
	$c\,\dot{f}$		48

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Make $c\bar{a}$ beat +60 times in 16 seconds
ce 0, *i. e.* a perfect IIId
df※ 0
cg※ 0
ac※ 0
$\bar{b}^b f$ downward — 24, *i. e.* $\frac{3}{4}$ths of cg
$b^b\bar{b}^b$ 0, *i. e.* a perfect octave
$\bar{b}^b e^b$ downward—43, *i. e.* $\frac{4}{3}$ths of cg
C$\bar{c}$ 0 an octave.

Other processes may be followed, and perhaps some of them better than the process here proposed. Thus, b^b and e^b may be tuned as perfect IIIds to d and g downwards. Also, as we proceed in tuning, we can prove the notes, by comparing them with other notes already tuned, &c. &c. &c.

We have directed to tune the two notes b^b and e^b by taking the leading Vth downwards. We should have come at the same pipes in the character of a※ and d※ in the process of tuning upwards by Vths. But this would not have produced precisely the same sounds, although, in our imperfect instruments, one key must serve for a※ and b^b. By tuning them as here directed, they are better fitted for the places in which they will be most frequently employed in our usual modulations.

80 Another system very fit for our instruments.

It may reasonably be asked, Why so much is sacrificed in order to preserve the IIIds perfect? Were they allowed to retain some part of the sharp temperament that is necessary for preserving the Vths perfect, we should perhaps improve the harmony. And since enlarging the Vth makes the tone greater, and therefore the limma *mi fa* much smaller, it will bring it nearer to the magnitude of a half tone; and this will be better suited for its double service of the sharp of the note below, and the flat of the note above. Accordingly, such a temperament is in great repute, and indeed is generally practised, although the VIths and the subordinate chords of full harmony are evidently hurt by it. Even Dr Smith recommends it as well suited to our defective instruments, and gives an extremely easy method of executing it by means of the beats. His method is to make the Vth and IIId beat equally fast, along with the key, the Vth flat, and the IIId sharp. He demonstrates (on another occasion), that concords beat equally fast with the same bass when their temperaments are inversely as the major terms of their perfect ratios. Therefore draw EG, and divide it in p, so that Ep may be to pG as 3 to 5. Then draw Cp, cutting gG in g', and EK in e'; and this temperer will produce the temperament we want. It will be found, that Ee' and Gg' are each of them 32 of their respective scales. Fig 2.

Therefore make cg beat 32 times in 16 seconds
Gc 32
Gd 24
Gb 24, and tune $b\bar{b}$
$d\bar{a}$ 36, and tune $a\bar{a}$
df※ 36
ae 27
ac※ 27
$e\bar{b}$ $40\frac{1}{2}$, proving $b\bar{b}$
eg※ $40\frac{1}{2}$
Fc $21\frac{1}{3}$, and tune Ff
Fa beat $21\frac{1}{3}$, proving a
$b^b f$ $28\frac{1}{2}$, and tune $b^b\bar{b}^b$
$e^b\bar{b}^b$ $38\frac{1}{2}$
$c\bar{c}$ 0.

It may be proper to add to all these instructions a caution about the manner of counting the clock while the tuner is counting the beats. If this is to continue for 16 seconds, let the person who counts the clock say *one* at the beat he begins with, and then telling them over *to himself*, let him say *done* instead of 17. Thus 16 intervals will elapse while the tuner is counting the beats. Were he to begin to count at *one*, and stop when he hears sixteen, he would get the number of beats in 15 seconds only.

We do not hesitate to say, that this method of tuning by beats is incomparably more exact than by the mere judgment of the ear. We cannot mistake more than one beat. This mistake in the concord of the Vth amounts to no more than $\frac{1}{1073}$th of a comma; and in the IIId it is only $\frac{1}{130}$. 81

82 Practical instructions.

It may be objected that it is fit only for the organ and instruments of continued sounds, but will not do for the quickly perishing sounds of the harpsichord. True, it is the only method worthy of that noble instrument, and this alone is a title to high regard. But farther; the accuracy attainable by it, renders it the only method fit for the examination of systems of temperament. Even for the harpsichord it is much more exact, and more certain in its process, than any other. It does not proceed, by a random trial of a flattened series of Vths, and a comparison with the resulting IIId, and a second trial, if the first be unsatisfactory. It says at once, let the Vth beat so many times in 16 seconds. Even in the second method, without counting, and merely by the equality of the beats of the Vth and IIId, the progress is easy. Both are tuned perfect. The Vth is then flattened a little, and the IIId sharpened;—if the Vth beat faster than the IIId, alter it first.

All difficulty is obviated by the simple contrivance of a variable pendulum, already described. This may be made exact by any person that will take a little pains; and when once made, will serve for every trial. When the ball is set to the proper number, and the pendulum set a swinging, we can come very near the truth by a very few trials.

N. B. In tuning a piano forte, which has always two strings to a key, we must never attempt tuning them both at once; the back unison of both notes of the concord must be damped, by sticking in a bit of soft paper behind it.

We hope that the instructions now given, and the application of them to two very respectable systems of temperament, are sufficient for enabling the attentive reader to put this method of tuning successfully in practice, and that he perceives the efficiency of it for attaining the desired end. But before we take leave of it, we beg leave to mention another circumstance, which evinces the just value of the general theory of the beats of imperfect consonances as delivered by Dr Smith.

83 Origin of the Tartinian sounds.

These reinforcements of sound, which are called *beatings*, are noises. If any noise whatever be repeated, with sufficient frequency, at equal intervals, it becomes a musical note, of a certain determinate pitch. If it recur 60 times in a second, it becomes the note C *fa ut*, or the double ...

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harpsichords, or the note of an open pipe eight feet long. Now there is a similar (we may call it the very same) reinforcement of sound in every concord. Where the pulse of one sound of the concord bisects the pulse of the other, the two sounds are more uniformly spread: but where they coincide, or almost coincide, the condensation of one undulation combines with that of the other, and there comes on the ear a stronger condensation, and a louder sound. This may be called a *noise*; and the equable and frequent recurrence of this noise should produce a musical note. If, for instance, *c* and *a* are sounded together: There is this noise at every third pulse of *c*, and every fifth pulse of *a*; that is, 80 times in a second. This should produce a note which is a 12th below *c*, and a 17th major below *a*; that is, the double octave below *f*, which makes 320 vibrations in a second. That is to say, along with the two notes *c* and *a* of the concord, and the compound sound, which we call the *concord of the VIth*, we should hear a third note FF in the bass. Now this is known to be a fact, and it is the grave harmonic observed by Romieu and Tartini about the year 1754, and verified by all musicians since that time. Tartini prized this observation as a most important discovery, and considered it as affording a foundation for the whole science of music. We see that it is all included in the theory of beats published five years before, namely, in 1749; and every one of these grave harmonics, or Tartinian sounds, as they have been called, are immediate consequences of this theory. The system of harmonious composition which Tartini has, with wonderful labour and address, founded on it, has therefore no solidity. It is, however, preferable to Rameau's, because it proceeds on a fact founded on the nature of musical sounds; whereas Rameau's is a mere whim, proceeding on a false assumption; namely, "that a musical sound is essentially accompanied by its octave, 12th, and 17th *in alto*."—This is not true, though such accompanyment be very frequent, and it be very difficult to prevent it. Mr Rameau ought to have seen this. Are these acute harmonics musical sounds or not? He surely will not deny this. Therefore they, too, are essentially accompanied by *their* harmonics, and this absolutely and necessarily *ad infinitum*; which is certainly absurd. We shall have a better occasion for considering this point when we describe the *Trumpet Marigni* in a future article.

We have taken notice of only two systems of temperament; both of them are systems of mean tones, and are in good repute as practicable methods. It would be almost an endless task to mention all the systems of temperament which have been proposed. Dr Smith, after having, with great ingenuity, appreciated the changes of harmoniousness that are induced on the different concords by the same temperament, and having assigned that proportion of temperament which renders them equally harmonious, each in its kind, gives a system of temperament, which he calls EQUAL HARMONY. Each concord (excepting the octave) is tempered in the inverse proportion of the product of the terms of its perfect ratio. It is very nearly equivalent to a division of the octave into 50 equal parts. We do not give any farther account of it here, although we think its harmony preferable to any thing that we have ever heard. We heard it, as executed for him, and under his inspection, by the celebrated harpsichord-maker Kirkmann, both when the instrument was yet in the hands of the maker, and afterwards by the ingenious author. We have also heard some excellent musicians declare, that the organ of Trinity college chapel at Cambridge was greatly improved in its harmony by the change made on its temperament under the inspection of Dr Smith. When we name Stanley, we presume that the authority will not be disputed. We mention this, because the writer in the Philosophical Transactions speaks of this system, with flattened major thirds, as of no value. But we do not give any farther account of it, because it is not suited to our instruments, which have but twelve sounds in the octave.

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The reader will please to recollect, that the great object of temperament is twofold. First, to enable us to transpose music from one pitch to another, so that we may make any note of the organ the fundamental of the piece. This undoubtedly requires a system approaching to one of mean tones, because the harmony must be the same in every key. This requires temperament, because a sound must be occasionally considered, either as the sharp of the note below it, or the flat of the one above. This cannot produce perfect harmony, because the limma of the perfect diatonic scale is greater than a half tone. Thus a temperament is necessary merely for the sake of the melody. But, *secondly*, the nature of modern music requires every note to be accompanied, or considered as accompanied, with full harmony. This is, in fact, the same thing with modulating on every different note as a fundamental; but it requires a much closer attention to the perfection of the intervals, because a defect or excess in an interval that would scarcely offend the ear, if the notes were heard in succession, is quite intolerable when they are sounded together. Here the difference between the major and minor tone is of almost as great moment as the difference of the limma from a semitone. The second object, therefore, is to obtain, in the compass of three octaves, as many good concords of full harmony; that is, consisting of a fundamental with its major third and its fifth, erect or inverted, as possible. There is no other harmony, although our notes have frequently a different situation and appearance. 81

82 Maxims often para-[illegible] very fallacious.

It is no wonder that, in a subject where we are yet to seek for a principle, the attempts to attain this object have been very various, and very gratuitous. The mathematicians, even in modern times, have allowed themselves to be led away by fancies about the simplicity and consequent perfection of ratios; and having no clear principle, it is no wonder that some of their deductions are contrary to experience. According to Euler, those ratios which are most perfect, that is, most simple, admit of least temperament. The octave is therefore infinitely perfect; for it is allowed by all, that it must not have the smallest temperament. A Vth must be less tempered than a IIId. Even the practical musician thinks that he has tempered these two concords equally, when the offensive quality of each is made equally so; but in this case it is demonstrable, that the Vth has been much more tempered than the IIId. But this could not be discovered till we got the theory of beats

Most of the mathematical musicians adhered to systems of mean tones; or, which are equivalent to such systems, giving similar harmonies on every key of the harp-

Temperament of the Scale of Music. harpsichord. This is surely the most natural, and is peculiarly suggested by the transposing of music from one pitch to another: but they differ exceedingly, and without giving any convincing arguments, in their estimation of the effects of the same temperament on different concords. Much of this, we apprehend, arises from disposition. Persons of a gay disposition relish the harmony of the IIId, and prefer a sharp to a flat temperament of this concord. Persons of a more pensive disposition, prefer such temperaments as allow the minor thirds to be more perfect.

87 Equal harmony rejected. But there are many, eminent both as performers and as theorists, who reject any system which gives the same harmonies on every note of the octave. They observe, that in the progress of the cultivation of music in Europe, the melodies of all nations have gradually approached to a certain uniformity. Certain cadences, closes, strains, and phrases, are becoming every day more common; and even in the conduct of a considerable piece of music, and the gradual but slow passage of the modulation from one key into another, there is a certain regularity. Nay, they add, that this cannot be greatly deviated from without becoming very offensive. We may remain ignorant of the cause of this uniformity, but its existence seems to prove that it arises from some natural principle; and therefore it ought to be complied with, and our temperaments should be accommodated to it. The result of this uniformity in the music of our times is, that the modulation on some keys is much less frequent than on others, and this frequency decreases in a certain order. Supposing that we begin on C. A piece of plain music seldom goes farther than G and F. A little more fancy and refinement leads the composer into D, or into B♭, &c. &c. It would therefore be desirable to adjust our temperaments so, that the harmonics in C shall be the best possible, and gradually less perfect in the order of modulation. Thus we shall, in our general practice, have finer harmony than if it were made equal throughout the octave; because the unavoidable imperfections are thrown into the least frequented places of the scale. The practical musicians add to this, that by such a temperament the different keys acquire characters, which fit each of them more particularly for the expression of different sentiments, and for exciting different emotions. This is very perceptible in our harpsichords as they are generally tuned. The major key of A is remarkably brilliant, that of F is as remarkably simple, &c.

We cannot say that we are altogether convinced by these arguments. The violin is unquestionably the instrument of the greatest powers. A concert of instruments of this kind, unembarrassed by the harpsichord, or any instruments incapable of occasional temperament, is the finest music we have. The performers make no such degradations of harmony, but keep it as perfect as possible throughout; and a violin performer is sensible of violence and constraint when he accompanies a keyed instrument into these unfrequented paths. Let him play the same music alone, and he will play it quite differently, and much more to his own satisfaction. We imagine, too, that much of the uniformity spoken of is the result of imitation and fashion, and even of the temperaments that we have preferred. There is an evident distinction in the native music of different nations. An experienced musician will know, from a few bars, whether an air is Irish, Scotch, or Polish. This distinction is in the modulation; which, in those nations, follows different courses, and should therefore, on the same principle, lead to different temperaments.

With respect to the variety of characters given to the different keys, we must acknowledge the fact. We have tuned a piano forte in the usual manner; but, instead of beginning the process with C, we began it with D. An excellent performer of voluntaries sat down to the instrument, and began to indulge his rich fancy; but he was confounded at every step: he thought the instrument quite out of tune. But when he was informed how it had been tuned, and then tried a known plain air on it, he declared it to be perfectly in tune. It is still very doubtful, however, whether we should not have much finer music, by equalising the harmony in the different keys, and trusting for the different expression so much spoken of to a judicious mixture of other notes called *discords*.

88 Cause of this uncertainty now removed by Dr Smith's theory. After all, the great uncertainty about the most proper temperament has remained so long undetermined, because we had no method of executing with certainty any temperament that was offered to the public. What signifies it on what principle it may be proper to flatten a Vth one fifth of a comma, and sharpen a VIth one seventh of a comma, unless we are able to do both the one and the other? Till Dr Smith published the theory of beats, the monochord was the only assistance we had: but however nicely it may be divided, it is scarcely possible to make the moveable bridge so steady and so accurate in its motion, that it will not sensibly derange the tension of the string. We have seen some very nice and costly monochords; but not one of them could be depended on to one-eighth of a comma. Even if perfect, they give but momentary sounds by pinching. The bow cannot be trusted, because its pressure changes the tension. Mr Watt's experiments with his monochord of continued sound shewed this evidently. A pitch-pipe with a sliding piston promises the greatest accuracy; but we are sadly disappointed, because the graduation of the piston cannot be performed by any mathematical rule. It must be pushed more than half way down to produce the octave, more than one-third to produce the Vth, &c. and this without any rule yet discovered. Thanks to Dr Smith we can now produce an instrument tuned exactly, according to any proposed system, and then submit it to the fair examination of musicians. Even the speculatist may now form a pretty just opinion of the merits of a system, by calculating, or measuring by such scales as we have proposed, the beats produced by the tempered concords in all parts of the octave. No one who has listened with attention to the rattling beats of a full organ, with its twelfth and sesquialter stops all sounding, will deny that they are hostile to all harmony or good music. We cannot be much mistaken in preferring any temperament in proportion as it diminishes the number of those beats. We should therefore examine them on this principle alone; attending more particularly to the beats of the third major, because these are in fact the loudest and most disagreeable; and we must not content ourselves with the beats of each concord with the fundamental of the full harmony, whether K—III—V, or K—4—VI, or K—3—V, or K—4—6, which sometimes occurs. We must attend equally to the beats of the two notes

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of accompanyment with each other: theſe are generally the moſt faulty.

This examination is neither difficult nor tedious. 1. Write down, in one column, the lengths of the ſtrings or diviſions of the monochord; in another write their logarithms; in a third the remainders, after ſubtracting each from the logarithm of the fundamental. 3. Have at hand a ſimilar table for the perfect diatonic ſcale. 4. Compare theſe, one by one, and note the difference, + or —, in a 4th column. Theſe are the temperaments of each note of the ſcale. 5. Compare every couple of notes which will compoſe a major or minor third, or a fifth, by ſubtracting the logarithm of the one note from that of the other. The differences are the intervals tempered. 6. Compare theſe with the perfect intervals of the diatonic ſcale, and note the differences, + or —, and ſet them down in a fifth column. Theſe are all the temperaments in the ſyſtem. 7. If we have uſed logarithms conſiſting of five decimal places, which is even more than ſufficient, conſider theſe numeral temperaments as the q of the formula given in n° 65. for calculating the beats, and then p is always = 540. Or we may make another column, in which the temperaments are reduced to ſome eaſy fraction of a comma.

90 ſrom Young.

We ſhall content ourſelves with giving one example; the temperament propoſed by Mr Young in the Philoſophical Tranſactions for 1800. It is contained in the following table.

1.	2.	3.	4.	5.		
				IIIds upward on		
C	100000	5.00000		C	135	Sharp.
C※	94723	4.97645	2355	G. F.	190	
D	89304	4.95087	4913	D. B♭	245	
E♭	83810	4.92330	7670	A. E♭	346	
E	79752	4.90174	9826	E. A♭	448	
F	74921	4.87461	12539	B. C※	494	
F※	71041	4.85151	14849	F※	540	
G	66822	4.82492	17508	3ds upward on		
G※	63148	4.80036	19964	A. E.	236	Flat.
A	59676	4.77580	22420	D. B.	291	
B♭	56131	4.74921	25079	G. F※	346	
B	53224	4.72610	27390	C. C※	448	
C	50000	4.69897	30103	F. G※	494	
				B♭. E♭	540	

Vths upward on

E♭. G※. C※. F※	perfect	Flat.
F. B♭. E. B	46	
C. G. D. A	116	

Interval of a comma	540
minor third	7918
major third	9691
fifth	17609

The firſt column of the above table contains the ordinary deſignations of the notes. The ſecond contains the correſponding lengths of the monochord The third contains the logarithms of column ſecond. The fourth contains the difference of each logarithm from the firſt. The next column contains, firſt, the temperaments of all the major thirds, having for their loweſt note the ſound correſponding to the letter. Thus 494, or $\frac{494}{540}$ of a comma, is the temperament of the IIId, B — D※, and C※ — F. Secondly, it contains all the minor thirds formed on the notes repreſented by the letters. The column below contains the temperaments of the Vths. *N. B.* Theſe temperaments are calculated by the author. We have found ſome of them a little different. Thus we make the temperament of C — G only 118. Below this we have ſet down the meaſures of the perfect intervals, which are to be compared with the differences of the logarithms in column third.

Temperament of the Scale of Muſic, [illegible]

91 Syſtem Kirnberger.

We preſume not to decide on the merits of this temperament: Only we think that the temperaments of ſeveral thirds, which occur very frequently, are much too great; and many inſtances of the 6th, which is frequent in the flat key, are ſtill more ſtrongly tempered. A temperament, however, which very nearly coincides with Dr Young's, has great reputation on the continent. This is the temperament by Mr Kirnbergher, publiſhed at Berlin in 1771, in his book called *Die Kunſt des reinen Satzes in der Muſik.* The eminent mathematician Major Templehoff has made ſome important obſervations on this temperament, and on the ſubject in general, in an eſſay publiſhed in 1775, Berlin. Dr Young's is certainly preferable.

The monochord is thus divided by Kirnbergher

C =	1,0000	F =	7500	B♭ =	5925
C※	9492	F※	7111	B	5313
D	8889	G	6667		5000
E♭	8437	G※	6328		
E	8000	A	5963		

We conclude this article (perhaps too long) by earneſtly recommending to perſons who are not mathematically diſpoſed, the ſliding ſcales, either circular or rectilineal, containing the octave divided into 301 parts; and a drawing of fig. 2. on card paper, of proper ſize, having the quarter comma about two inches, and a ſeries of ſcales correſponding to it. This will ſave almoſt the whole of the calculation that is required for calculating the beats, and for examining temperaments by this teſt. To readers of more information, we earneſtly recommend a careful peruſal of Smith's Harmonics, ſecond edition. We acknowledge a great partiality for this work, having got more information from it than from all our patient ſtudy of the moſt celebrated writings of Ptolemy, Huyghens, Euler, &c. It is our duty alſo to ſay, that we have got more information concerning the muſic of the Greeks from Dr Wallis's appendix to his edition of Porphyrius's Commentary on Ptolemy's Harmonics, than from any other work

TEMPLARS. In the account of this order, which is publiſhed in the *Encyclopædia*, we have, with many others, ſuppoſed that the guilt of which they were accuſed at the ſuppreſſion of the order was leſs enormous than their enemies alleged. For the honour of human nature, we are ſtill unwilling to believe that this was not the caſe. Juſtice, however, compels us to admit, that the Abbé Barruel has brought together ſuch a cloud of witneſſes againſt the Templars, that we know not how to reſiſt their evidence; and that he has completely proved, that *Philip le Bel* was not influenced by avarice when he ſuppreſſed that order in France "It has been ſaid, that he and Clement V. had concerted between them the diſſolution of the Templars. The falſity of ſuch an aſſertion is evident on the inſpection of their letters. Clement V. at firſt will give no credit

dict to the accusations against the Templars; and even when he receives incontestable proofs from Philip le Bel, he had still so little concerted the plan with that Prince, that every step taken by the one or the other occasions disputes on the rights of the church or of the throne.

"It was also said, that the king wished to seize on the great riches of these knights: but at the very commencement of his proceedings against the order, he solemnly renounced all share in their riches; and perhaps no Prince in Christendom was truer to his engagement. Not a single estate was annexed to his domain; and all history bears testimony to the fact.

"We next hear of a spirit of revenge which actuated this Prince; and during the whole course of this long trial, we do not hear of a single personal offence that he had to revenge on the Templars. In their defence, not the most distant hint, either at the revengeful spirit, or at any personal offence against the king, is given: so far from it, until the period of this great catastrophe, the grand master of the order had been a particular friend of the king's, who had made him godfather to one of his children.

"In fine, the rack and torture is supposed to have forced confessions from them which otherwise they never would have made; and in the minutes, we find the avowal of at least 200 knights all made with the greatest freedom, and without any coercion. Compulsion is mentioned but in the case of one person; and he makes exactly the same avowal as 12 other knights, his companions, freely made (A). Many of these avowals were made in councils where the bishops begin by declaring, that all who had confessed through fear of the torture should be looked upon as innocent, and that no Knight Templar should be subjected to it (B). The Pope Clement V. was so far from favouring the king's prosecutions, that he began by declaring them all to be void and null. He suspended the archbishops, bishops, and prelates, who had acted as inquisitors in France. The king accuses the Pope in vain of favouring the Templars; and Clement is only convinced after having been present at the interrogatories of 72 knights at Poictiers, in presence of many bishops, cardinals, and legates. He interrogated them, not like a judge who sought for criminals, but like one who wishes to find innocent men, and thus exculpate himself from the charge of having favoured them. He hears them repeat the same avowals, and they are freely confirmed. He desired that these avowals should be read to them after an interval of some days, to see if they would still freely persevere in their depositions. He hears them all confirmed. *Qui perseverantes in illis, eas expresse et sponte prout recitatæ fuerant approbårunt.* He wished still further to interrogate the grand master and the principal superiors, *præceptores majores*, of the divers provinces of France, Normandy, Poitou, and of the Transmarine countries. He sent the most venerable persons to interrogate those of the superiors, whose age or infirmities hindered them from appearing before him. He ordered the depositions of their brethren to be read to them, to know if they acknowledged the truth of them. He required no other oath from them than to answer freely and without compulsion; and both the grand master and the superiors of these divers provinces depose and confess the same things, confirm them some days after, and approve of the minutes of their depositions taken down by public notaries. Nothing less than such precautions could convince him of his error: it was then only that he revoked his menaces and his suspension of the French bishops, and that he allows the king to proceed in the trials of the Templars. Templars

"Let such pretexts be forgotten, and let us only dwell on the avowals which truth alone forced from these criminal knights.

"Their depositions declare, that the Knights Templars, on their reception, denied Christ, trampled on the cross, and spit upon it; that Good Friday was a day which was particularly consecrated to such outrages; that they promised to prostitute themselves to each other for the most unnatural crimes; that every child begotten by a Templar was cast into the fire; that they bound themselves by oath to obey, without exception, every order coming from the grand master; to spare neither sacred nor prophane; to look upon every thing as lawful when the good of the order was in question; and, above all, never to violate the horrible secrets of their nocturnal mysteries, under pain of the most terrible chastisements (C).

"In making their depositions, many of them declared they had only been forced into these horrors by imprisonment and the most cruel usage; that they wished, after the example of many of their brethren, to pass into other orders, but that they did not dare, fearing the power and vengeance of their order; that they had secretly confessed their crimes, and had craved absolution. In this public declaration, they testified, by their tears, the most ardent desire of being reconciled to the church.

"All repeat the same deposition, except three, who declare they have no knowledge of the crimes imputed to their order. The Pope, not content with this information taken by men of religious orders and by French noblemen, requires that a new trial should take place in Poitou before cardinals and others whom he himself nominates: Again, with the same freedom, and for the third time, the grand master and other chiefs, in presence of Clement V. repeat their depositions. Molay even requested, that one of the lay brothers, who was about his person, should be heard, and this brother confirms the declaration. During many years these informations were continued and renewed at Paris, in Champagne, in Normandy, in Quercy, in Languedoc, in Provence. In France alone, above 200 avowals of the same nature are to be found: nor did they vary in England, where, at the synod of London held in 1311, 78 English knights were heard, and two whole months were spent in taking informations and in verifying their declarations. Fifty-four Irish were also heard, and many Scotch, in their respective countries. It was in consequence of these declarations that the order of the Templars was abolished in those kingdoms, and that the parliament

(A) *Layette*, N° 20. *Interrog. made at Caen.*
(B) See the *Council of Ravenna. Rubeus Hist. Raven.* lib. vi.
(C) See the *Vouchers brought by Dupuy*, and *Extract of the Registers.*

Templars, Templeman.

parliament disposed of their goods (D). The same declarations were taken and proved in Italy, at Ravenna, at Bologna, at Pisa, and at Florence, though in all these councils the prelates were very ready to absolve all those knights who could succeed in their justifications.

"I would willingly assert (continues the Abbé), that it was the smaller part of the Templars who suffered themselves to be carried away by such abominations. Some even at Paris were declared innocent. In Italy a still greater number were absolved; of all those who were judged at the councils of Mayence and Salamanca, none were condemned: and hence we may conclude, that of the 9000 houses belonging to the order, many had not been tainted, and that whole provinces were to be excepted from the general stain of infamy. But the condemnations, the juridical depositions, the method of initiating the knights, almost become general; the secrecy of their receptions, where neither prince, nor king, nor any person whatever, could be present during the last half century, are so many testimonies which corroborate the divers accusations contained in the articles sent to the judges; that is to say, that at least two-thirds of the order knew of the abominations practised without taking any steps to extirpate them. *Quod omnes, vel quasi duæ partes ordinis scientes dictos errores corrigere neglexerint.*

"This certainly cannot mean that two thirds of the knights had equally partaken of these abominations. It is evident, on the contrary, that many detested them as soon as they were acquainted with them; and that others only submitted to them, though initiated, after the harshest treatment and most terrible threats. Nevertheless, this proves, that the greatest part of these knights were criminal, some through corruption, others through weakness or connivance; and hence the dissolution of the order became necessary."

TEMPLEMAN (Peter), M. D. the son of an eminent attorney at Dorchester in the county of Dorset, by Mary daughter of Robert Haynes, was born March 17, 1711, and was educated at the Charter-house (not on the foundation), whence he proceeded to Trinity-college, Cambridge, and there took his degree of B. A. with distinguished reputation. During his residence at Cambridge, by his own inclination, in conformity with that of his parents, he applied himself to the study of divinity, with a design to enter into holy orders; but after some time, from what cause we know not, he altered his plan, and applied himself to the study of physic. In the year 1736, he went to Leyden, where he attended the lectures of Boerhaave, and the professors of the other branches of medicine in that celebrated university, for the space of two years or more. About the beginning of 1739, he returned to London, with a view to enter on the practice of his profession, supported by a handsome allowance from his father. Why he did not succeed in that line was easy to be accounted for by those who knew him. He was a man of a very liberal turn of mind, of general erudition, with a large acquaintance among the learned of different professions, but of an indolent, inactive disposition; he could not enter into juntos with people that were not to his liking; nor cultivate the acquaintance to be met with at tea-tables; but rather chose to employ his time at home in the perusal of an ingenious author, or to spend an attic evening in a select company of men of sense and learning. In this he resembled Dr Armstrong, whose limited practice in his profession was owing to the same cause. In the latter end of the year 1750 he was introduced to Dr Fothergill by Dr Cuming, with a view of instituting a Medical Society, in order to procure the earliest intelligence of every improvement in physic from every part of Europe. At the same period he tells his friend, "Dr Mead has very generously offered to assist me with all his interest for succeeding Dr Hall at the Charter house, whose death has been for some time expected. Inspired with gratitude, I have ventured out of my element (as you will plainly perceive), and sent him an ode." Dr Templeman's epitaph on Lady Lucy Meyrick (the only English copy of verses of his writing that we know of), is printed in the eighth volume of the "Select Collection of Miscellany Poems, 1781." In 1753 he published the first volume of "Curious Remarks and Observations in Physic, Anatomy, Chirurgery, Chemistry, Botany, and Medicine; extracted from the History and Memoirs of the Royal Academy of Sciences at Paris;" and the second volume in the succeeding year. A third was promised, but we believe never printed. It appears, indeed, that if he had met with proper encouragement from the public, it was his intention to have extended the work to twelve volumes, with an additional one of index, and that he was prepared to publish two such volumes every year. His translation of "Norden's Travels" appeared in the beginning of the year 1757; and in that year he was editor of "Select Cases and Consultations in Physic, by Dr Woodward," 8vo. On the establishment of the British Museum, in 1753, he was appointed to the office of keeper of the reading-room, which he resigned on being chosen, in 1760, secretary to the then newly instituted Society of Arts, Manufactures, and Commerce. In 1762, he was elected a corresponding member of the Royal Academy of Science of Paris, and also of the Œconomical Society at Berne. Very early in life Dr Templeman was afflicted with severe paroxysms of an asthma, which eluded the force of all that either his own skill, or that of the most eminent physicians then living, could suggest to him; and it continued to harass him till his death, which happened September 23, 1769. He was esteemed a man of great learning, particularly with respect to languages; spoke French with great fluency, and left the character of a humane, generous, and polite member of society.

Templeman, Terané.

TERANE', a town in Egypt, situated on what Mr Browne calls the *left* of the most western mouth of the Nile, at a very small distance from the river. Its latitude is 30° 24'. The buildings are chiefly unburned brick, though there are also some of stone. The town and district, containing several villages, belonged, before the French invasion, to Murad Bey, who usually entrusted its government, and the collection of its revenue, to one of his Cashefs. That revenue arises principally from natrôn (See NATRUM, *Encycl.*), found in

(D) Vide *Valsinger in Edvardum* II. *et Ypodigma Neustriæ apud Dupuy.*—*Essai de Fred. Nicolai.*

in great quantities in certain lakes about thirty five miles from Terané; and it is on account of these lakes only that the town is worthy of notice in this work; for though there are many columns in its neighbourhood, which indicate the site of ancient structures, none of them have inscriptions ascertaining their antiquity.

The eastern extremity of the most western lake Mr Browne found to be 30° 31′ North. No vegetation appears, except reeds, on the margin of the lake, which is very irregular in its form; so that it is not easy to say what may be the quantity of ground covered with water. It is higher in winter than in summer; and when it was visited by our author, its breadth did not exceed a mile, though its length was nearly four. Towards the end of the summer, it is said, these lakes are almost dry; and the space that the water has retired from is then occupied by a thick deposition of salt. Not far removed from the eastern extremity, a spring rises with some force, which much agitates the rest of the water. Close to that spring the depth was far greater than Mr Browne's height; in other parts it was observable that it did not generally exceed three feet. The thermometer near this spring stood at 76, while in the open air it was 87. The more western lake differs not materially from the eastern in size, form, or productions. The colour of the water in both is an imperfect red; and where the bottom is visible, it appears almost as if covered with blood. Salt, to the thickness of five or six inches, lies constantly in the more shallow parts. The surface of the earth, near the lake, partakes more or less generally of the character of natrôn, and, in the parts farthest removed, offers to the foot the slight resistance of ploughed ground after a slight frost. The soil is coarse sand. The water of the lake, on the slightest evaporation, immediately deposits salt. There is a mountain not far from the lakes, where natrôn is found in insulated bodies, near the surface, of a much lighter colour than that produced in the lake, and containing a greater portion of alkali. How thick the substance of natrôn commonly is in the lake, our author did not accurately determine; but those employed to collect it report, that it never exceeds a cubit, or common pike; but it appears to be regenerated as it is carried away. If ever it should be brought to supersede the use of barilla, the quantity obtainable seems likely to answer every possible demand.

TEREBRATULÆ (ANOMIÆ, *Lin.* see that article *Encycl.*) have been supposed not to exist now but as petrified shells. This, however, is a mistake. The anomia is an inhabitant of every region, and has existed in every age. As many terebratulæ were caught by Perouse's people during his voyage of discovery, and as Lamanon the naturalist thought they should be considered as a genus by themselves, he has given us the following description of the *anomia*, or, as he calls it, *terebratula*, on the coast of Tartary:

The length of the shell varies from six to twenty lines, and its breadth from five to eighteen; there are, however, considerable varieties of proportion between different individuals, besides those arising from the different ages of the animal. It would be improper, therefore, to distinguish the various species of anomiæ by the proportion of their shells. The waving lines on the edges of the shell are equally defective, as distinctive characters; for our author observed in the same species the shell approaching or receding indifferently from the circular form, and, in some, the edges of the valves are on the same plane; whereas in others, one of the valves forms a salient angle in the middle of its curve, and the other a re-entering angle

Terebratulæ.

The shell is of a moderate thickness, about that of a common muscle; it is somewhat transparent, convex like the cockle: neither of the shells is more sensibly arched than the other; that, however, which has the spur, is rather the most so, especially in the superior part.

On the surface of the shell are seen a number of slight transverse depressions, of a semicircular waved form, which reach the part where the shell ceases to be circular, in order to form the angle which supports the summit.

These striæ are covered with a very thin and slightly-adhering periosteum; in some specimens there are from one to three shallow broad depressions, radiating insensibly from the centre of the shell, and becoming more marked as they approach the edges, where they form, with the corresponding parts of the other shell, those salient and re-entering angles which have been mentioned. The periosteum is rather more firmly fixed on the latter angles than on the former.

The shells are equal in the rounded part of their edge, and close very exactly; however, towards the summit, the spur of one of the shells reaches considerably beyond the other shell, consequently they are unequal, as in oysters.

The spur, or summit, is formed by the folding from within of the edge of the shell, and the elongation of its upper part. The folded edges form an oval aperture of a moderate size, through which the animal extends the muscle, by means of which it attaches itself to other substances. This shell is not, therefore. perforated, as its name of terebratula would seem to imply, the opening not being worked in one of the shells, but formed by the elongation of one shell, the folding in of its edges, and the approach of the other shell. The summit is not pointed, but round.

The ligament, as in the oyster, is placed between the summits, and does not appear on the outside; it adapts itself to the pedicle of the animal. As the summit takes up a considerable part of the shell, the valves are only capable of opening a very little without running the risk of being broken. It is very firm, though slender, and not easily to be discovered, being fixed in a small groove, which is filled up when the shell is shut by the corresponding part of the opposite shell. This ligament preserves its texture, even for a considerable time after the shell is emptied and become dry.

Oysters are without a hinge, the teeth which form it in many other shells not existing in them. The anomia has been considered as an oyster, because its hinge or teeth have not been examined: they are not visible indeed in the fossile specimens; but in opening them when alive, the teeth composing the hinge are sufficiently visible, being even much larger than in the greater part of bivalve shells. The fossil terebratulæ are almost always found with their shells closed; whereas the other bivalves have usually theirs either open or separated: the reason of this seems to arise from the nature of the hinge, that of the anomia not allowing it

to

Terebratulæ.

to separate, and the ligament, which is very tight, contributing to keep the two shells united. The teeth which form the hinge of the anomia approach very near to those of the *spondyle*, described by M. Adanson. In this last they are formed by two rounded projections, and in the anomia by the same a little elongated. It is above these teeth that the ligament is placed in the larger shell: there are between it and the teeth two cavities, one on each side, which serve to receive the teeth of the other valve. The teeth of the larger shell have, besides, a slight projection, which fits into a longitudinal furrow in the other shell in front of the teeth.

The substance which covers the inside of the shell holds, as in oysters, a middle place between *nacre* and the interior substance of shells, which are destitute of it. The degree of its lustre, polish, and thickness, varies with the age and circumstances of individuals.

The colour of the teeth is always white; that of the outer surface of the shell verges more or less to the ochry red, especially on the border. The inside has also a very slight tint of this colour, on a varying greyish-white ground.

There is visible on each side of the shell the impression of two very distinct tendons; a circumstance which forms a very essential difference between this genus and that of the oyster: this latter having only one tendon arising from the middle of the body. The impressions of the tendon in the largest shell are oblong, situate near the summit, and hollowed; each of them has curved transverse ridges, divided into two parts by a longitudinal furrow, representing the wings of certain insects. In the other valve the insertions have a different form; their situation is the same, but they are very irregularly rounded and encompassed by two fulcations, which are separated from each other by an intervening ridge, and then are continued in a right line towards the opening of the shell as far as about two thirds of its length. That part of the summit of the shell along which the pedicle of the animal passes, is longitudinally striated in the larger shell, of which the middle stria is the deepest: the longitudinal striæ are divided into equal parts by a transverse depression. There are no similar marks on the other shell.

Our author dissected the animal itself, and found what he calls the *manteau* of the anomia, formed of a very fine membrane, lining the inside of both shells, and containing the body of the animal. Its origin is of the same breadth as the hinge of the shell, whence it divides into two lobes, lining both the shells: it forms, therefore, only a single aperture, terminating at each end of the hinge, and of the same breadth with the interior surface of the shell: it appears to have only one trachea, which is formed by the two lobes of the manteau.

Our naturalist having opened the shell, divided the ligament as delicately as possible, unfixed the hinge, and detaching from the larger shell the lobe of the manteau, turned over the body of the animal. This operation exposed to view the large muscles which adhered to the shell; they are soft, membranous, and, as it were, fleshy on the inside, being covered with small sanguiferous glands. From the lower part of each muscle there proceeds a pretty strong tendon, which reaches to the extremity of the manteau; they run parallel to the edge of the shell, and at a considerable distance from each other; and are each enclosed in a sort of flatted sac, of the shape of a ribbon, which is filled with a red viscid matter. It appears that the place of insertion of the muscles, as well as the muscles themselves, which extend along the lobe of the manteau, furnish real blood, which is contained in three small fleshy red glandular bodies of unequal size, which are visible after having taken off the muscles; perhaps these constitute the heart of the animal.

The muscles which are inserted into the other shell are also divided into several parts: some are seen extending along the corresponding lobe of the manteau; many others rise up in a kind of tuft, which is fixed into the shell above: some again subdivide into such minute ramifications as not to allow of tracing their course, even with the assistance of a microscope; but others, more apparent, contribute to the formation of the pedicle which passes through the opening left between the two shells, is connected to each of them by several fibres, and fixes itself to some external body, principally to other bivalves. The muscles of the anomia have therefore three attachments, namely, to the inner surface of each shell, and to some external body.

The form of the pedicle is cylindrical, being enclosed in a muscular substance, which contains several fibres; it is from a line to a line and a half long, and two thirds in diameter. It adheres so forcibly to different substances, as that the animal, and all the muscles which contribute to the formation of the pedicle, may more easily be torn through than the pedicle detached from the place of its adhesion. The glutinous substance which connects them to each other, resists even the heat of boiling water. It is by means of this pedicle that the animal raises its shell so as to be, while in the water, in a position inclined to the horizon. The smallest valve is always the lowest, being that upon which the animal rests; the superior one being the larger, and serving as a covering. Our author thinks the animal has the power of loco-motion.

After raising the lobe of the manteau he observed the ears. They are large, composed of two membranaceous laminæ on each side, of which the superior is the narrower. These laminæ are connected to each other by a thin membrane, so as to form only a single pouch. They have on their edges long fringes, which hang loose upon the manteau; but a very remarkable circumstance is, that their ears are supported by little bones like those of fish. The form of the ears is that of an arch; they are separated from each other on their lower part, where the fringes are the longest; so that the two ears on one side are perfectly distinct from those on the other side. The commencement of the ears is at the teeth of the hinge.

Between the ears are situate the stomach, œsophagus, and mouth; the whole forming a triangle, of which the mouth is the base. It is placed at the side of the hinge, and consists of a large transverse opening without lips or jaw-bone. The œsophagus is very short, but is capable of elongation when the animal opens its mouth. The stomach, which is of the shape of a pointed sac, is connected by a membrane to the bones of the ear. On opening the stomach, he found a small shrimp half digested.

At the bottom of the stomach is seen the intestine, of which it is, as it were, a continuation. It is extremely short, not exceeding half a line in a shell fifteen

Terebratulæ, Ternai.

lifice across, and is composed of a very slender membrane. The excrements are discharged upon the lobes of the manteau, but they are easily thrown out by the motions of the two lobes.

The little bones of the ears, already mentioned, had not formerly been observed in any of the testaceous animals; whence the terebratulæ approach nearer to fish than the inhabitants of any other shell. In the anomiæ which are preserved in cabinets, there is found only a very small portion of these bones, whence they have obtained the improper appellations of *tongue* or *fork*, which indicate only the form of the fragments, and not their use.

The small bones of the ears are composed of several pieces, the principal of which is of an oval form; it springs from the side of the hinge, of which it appears to be a continuation; thence it extends about two-thirds of the breadth of the shell, where it is reflected, and rests against the upper part of the fork, to the branches of which it is united by a simple superposition; a kind of articulation very common among the numerous small bones that compose the heads of fish. The fork extends from the summit a little more than one-third of the breadth of the shell: it is formed by a pivot which divides into two long and pointed branches; these are remarkably brittle, and support the extremities of the bones of the larger ears. The lamina, which composes a second set of ears, rests upon a curved bone, which on one side is attached to the inferior internal part of the bone of the larger ears, and on the other reaches to the side of the mouth of the animal, where it is united to another flat little bone, which is applied to a similar bone on the other side. These last little bones are exactly below the membrane which forms the mouth. All these bones are flat, very brittle, and surrounded with fibres and membranes. By their articulations the ears are enabled to move; they also support the body of the animal, which touches neither of the shells, but remains between them as upon tressels. The space between the branches of the bones of the ears is filled up with a transparent firm membrane; at the base of the fork is a similar one, and a perpendicular partition dividing the space occupied by the body of the animal from the rest of the shell. There are two orifices in this membrane communicating with the space between the two lobes of the manteau, and which serves as a trachea; for we have remarked, in the description of the manteau, that the two lobes are entirely separated from each other, and therefore do not form a real trachea.

From this description, it follows that the anomia ought to be separated from the genus oyster, since it has a toothed hinge, several ligaments, and an interior organization wholly different; neither ought it to be confounded with the cockle, the shells of which are both equal, and are destitute of any sensible periosteum, without reckoning other differences. It has still less analogy with the other bivalves, and therefore ought to constitute a peculiar genus; the species of which, both fossil and living, are very numerous.

See Plate XLIII. where fig. 1. is a front view of a terebratula of middle size. Fig. 2. is a view of the internal structure.—A A, laminæ of the superior ears—B B, laminæ of the inferior—C, the stomach—D, the anus—E E, the manteau—F, the œsophagus.

TERNAI, the name given by Perouse to a very fine bay which he discovered on the coast of Tartary, in Lat. 45° 13′ North, and in Long. 135° 9′ East from Paris. The bottom is sandy, and diminishes gradually to six fathoms within a cable's length of the shore. The tide rises five feet; it is high water at $8^h\ 15^m$ at full and change; and the flux and reflux do not alter the direction of the current at half a league from the shore.

"Five small creeks (says La Perouse), similar to the sides of a regular polygon, form the outline of this roadstead; these are separated from each other by hills, which are covered to the summit with trees. Never did France, in the freshest spring, offer gradations of colour of so varied and strong a green; and though we had not seen, since we began to run along the coast, either a single fire or canoe, we could not imagine that a country so near to China, and which appeared so fertile, should be entirely uninhabited. Before our boats had landed, our glasses were turned towards the shore, but we saw only bears and stags, which passed very quietly along the sea side. The same plants which grow in our climates carpeted the whole soil, but they were stronger, and of a deeper green; the greater part were in flower. Roses, red and yellow lilies, lilies of the valley, and all our meadow flowers in general, were met with at every step. Pine trees covered the tops of the mountains; oaks began only half way down, and diminished in strength and size in proportion as they came nearer the sea; the banks of the rivers and rivulets were bordered with willow, birch, and maple trees, and on the skirts of the forests we saw apple and medlar trees in flower, with clumps of hazle nut trees, the fruit of which already made its appearance. Our surprise was redoubled, when we reflected on the population which overburdens the extensive empire of China, so that the laws do not punish fathers barbarous enough to drown and destroy their children, and that this people, whose polity is so highly boasted of, dares not extend itself beyond its wall, to draw its subsistence from a land, the vegetation of which it would be necessary rather to check than to encourage. At every step after we had landed, we perceived traces of men by the destruction they had made; several trees, cut with sharp-edged instruments; the remains of ravages by fire were to be seen in several places, and we observed some sheds, which had been erected by hunters in a corner of the woods. We also found some small baskets, made of the bark of birch trees, sewed with thread, and similar to those of the Canadian Indians; rackets for walking on the snow; in a word, every thing induced us to think that the Tartars approach the borders of the sea in the season for hunting and fishing; that they assemble in colonies at that period along the rivers; and that the bulk of the nation live in the interior of the country on a soil perhaps better calculated for the multiplication of their immense flocks and herds."

Our navigators caught in the bay vast quantities of fine fish, such as cod, harp-fish, trout, salmon, herrings, and plaice; but though game was plenty on shore, they had no success in hunting. The meadows, so delightful to the sight, could scarce be crossed; the thick grass was three or four feet high, so that they found themselves in a manner buried in it, and they were under the perpetual dread of being bitten by serpents, of which

which they saw a great number on the banks of the rivulets. They found, however, immense quantities of small onions, sorrel, and celery; which, together with the fresh fish, served as antidotes against the scurvy.

TERRE-PLEIN, or TERRE PLAIN, in fortification, the top, platform, or horizontal surface of the rampart, upon which the cannon are placed, and where the defenders perform their office. It is so called because it lies level, having only a little slope outwardly to counteract the recoil of the cannon. Its breadth is from 24 to 30 feet; being terminated by the parapet on the outer side, and inwardly by the inner talus.

TERRELLA, or little earth, is a magnet turned of a spherical figure, and placed so as that its poles, equator, &c. do exactly correspond with those of the world. It was so first called by Gilbert, as being a just representation of the great magnetic globe we inhabit. Such a terrella, it was supposed, if nicely poised, and hung in a meridian like a globe, would be turned round like the earth in 24 hours by the magnetic particles pervading it; but experience has shewn that this is a mistake.

TETRAEDRON, or TETRAHEDRON, in geometry, is one of the five Platonic or regular bodies or solids, comprehended under four equilateral and equal triangles. Or it is a triangular pyramid of four equal and equilateral faces.

TETRAGON, in geometry, a quadrangle, or a figure having four angles. Such as a square, a parallelogram, a rhombus, and a trapezium. It sometimes also means peculiarly a square.

TETRAGON, in astrology, denotes an aspect of two planets with regard to the earth, when they are distant from each other a fourth part of a circle, or 90 degrees. The tetragon is expressed by the character □, and is otherwise called a square or quartile aspect.

THEBES, in Egypt. Having in the *Encyclopædia* given Mr Bruce's account of this ancient city, which represents it as having been a paltry place, so contrary to the description of Homer, justice to the father of poetry requires that we here notice what has been said of it by a subsequent traveller, who remained three days among its ruins. According to Mr Browne, "the massy and magnificent forms of the ruins that remain of ancient Thebes, the capital of Egypt, the city of Jove, the city with 100 gates, must inspire every intelligent spectator with awe and admiration. Diffused on both sides of the Nile, their extent confirms the classical observations, and Homer's animated description rushes into the memory:

'Egyptian Thebes, in whose palaces vast wealth is stored; from each of whose hundred gates issue two hundred warriors, with their horses and chariots.'

"These venerable ruins, probably the most ancient in the world, extend for about three leagues in length along the Nile. East and west they reach to the mountains, a breadth of about two leagues and a half. The river is here about three hundred yards broad. The circumference of the ancient city must therefore have been about twenty-seven miles.

"In sailing up the Nile, the first village you come to within the precincts is Kourna, on the west, where there are few houses, the people living mostly in the caverns. Next is Abuhadjadj, a village, and Karnac, a small district, both on the east. Far the largest portion of the city stood on the eastern side of the river. On the south-west Medinet-Abu marks the extremity of the ruins; for Arment, which is about two leagues to the south, cannot be considered as a part.

"In describing the ruins, we shall begin with the most considerable, which are on the east of the Nile. The chief is the Great Temple, an oblong square building of vast extent, with a double colonnade, one at each extremity. The massy columns and walls are covered with hieroglyphics; a labour truly stupendous. 1. The Great Temple stands in the district called *Karnac*. 2. Next in importance is the temple at *Abulhadjadj*. 3. Numerous ruins, avenues marked with remains of sphinxes, &c. On the west side of the Nile appear, 1. Two colossal figures, apparently of a man and woman, formed of a calcareous stone like the rest of the ruins. 2. Remains of a large temple, with caverns excavated in the rock. 3. The magnificent edifice styled the *palace of Memnon*. Some of the columns are about forty feet high, and about nine and a half in diameter. The columns and walls are covered with hieroglyphics. This stands at *Kourna*. 4. Behind the palace is the passage styled *Biban-el Meluk*, leading up the mountain; at the extremity of this passage, in the sides of the rock are the celebrated caverns known as the sepulchres of the ancient kings."

Though Mr Browne agrees with Pococke and Bruce, that the passage in Homer refers not to the gates of the city, he is yet of opinion, contrary to them, that Thebes had been a walled town. He says, indeed, that some faint remains of its surrounding wall are visible at this day; and he thinks that he discovered the ruins of three of its gates, though he does not affirm this with absolute confidence.

THEODOSIUS, a celebrated mathematician, flourished in the times of Cicero and Pompey; but the time and place of his death are unknown. This Theodosius, the Tripolite, as mentioned by Suidas, is probably the same with Theodosius the philosopher of Bythinia, who, Strabo says, excelled in the mathematical sciences, as also his sons; for the same person might have travelled from the one of those places to the other, and spent part of his life in each of them; like as Hipparchus was called by Strabo the Bythinian, but by Ptolemy and others the Rhodian. B.C.

Theodosius chiefly cultivated that part of geometry which relates to the doctrine of the sphere, concerning which he published three books. The first of these contains 22 propositions; the second, 23; and the third, 14; all demonstrated in the pure geometrical manner of the ancients. Ptolemy made great use of these propositions, as well as all succeeding writers. These books were translated by the Arabians, out of the original Greek, into their own language. From the Arabic the work was again translated into Latin, and printed at Venice. But the Arabic version being very defective, a more complete edition was published, in Greek and Latin, at Paris 1558, by John Pena, Regius Professor of astronomy. And Vitello acquired reputation by translating Theodosius into Latin. This author's works were also commented on and illustrated by Clavius, Heleganius, and Guarinus, and lastly by De Chales, in his Cursus Mathematicus. But that edition of Theodosius's Spherics, which is now most in use, was translated and published by our countryman the learned Dr Barrow,

fow, in the year 1675, illustrated and demonstrated in a new and concise method. By this author's account, Theodosius appears, not only to be a great master in this more difficult part of geometry, but the first considerable author of antiquity who has written on that subject.

Theodosius, too, wrote concerning the Celestial Houses; also of Days and Nights; copies of which, in Greek, were in the King's library at Paris. Of which there was a Latin edition, published by Peter Dasypody, in the year 1572.

THEON, of Alexandria, a celebrated Greek philosopher and mathematician, who flourished in the 4th century, about the year 380, in the time of Theodosius the Great; but the time and manner of his death are unknown. His genius and disposition for the study of philosophy were very early improved by close application to all its branches; so that he acquired such a proficiency in the sciences as to render his name venerable in history, and to procure him the honour of being president of the famous Alexandrian school. One of his pupils was the admirable Hypatia, his daughter, who succeeded him in the presidency of the school; a trust which, like himself, she discharged with the greatest honour and usefulness. See her life, *Encycl.*

The study of Nature led Theon to many just conceptions concerning God, and to many useful reflections in the science of moral philosophy. Hence, it is said, he wrote with great accuracy on Divine Providence. And he seems to have made it his standing rule, to judge the truth of certain principles, or sentiments, from their natural or necessary tendency. Thus, he says, that a full persuasion that the Deity sees every thing we do, is the strongest incentive to virtue; for he insists, that the most profligate have power to refrain their hands, and hold their tongues, when they think they are observed, or overheard, by some person whom they fear or respect. With how much more reason then, says he, should the apprehension and belief, that God sees all things, restrain men from sin, and constantly excite them to their duty? He also represents this belief concerning the Deity as productive of the greatest pleasure imaginable, especially to the virtuous, who might depend with greater confidence on the favour and protection of Providence. For this reason, he recommends nothing so much as meditation on the presence of God: and he recommended it to the civil magistrate as a restraint on such as were profane and wicked, to have the following inscription written, in large characters, at the corner of every street—GOD SEES THEE, O SINNER.

Theon wrote notes and commentaries on some of the ancient mathematicians. He composed also a book, intitled *Progymnasmata*, a rhetorical work, written with great judgment and elegance; in which he criticised on the writings of some illustrious orators and historians; pointing out, with great propriety and judgment, their beauties and imperfections; and laying down proper rules for propriety of style. He recommends conciseness of expression, and perspicuity, as the principal ornaments. This book was printed at Basle in the year 1541; but the best edition is that of Leyden, in 1626, in 8vo.

THEOPHILANTHROPISTS, a sect of deists, who, in September 1796, published at Paris a sort of catechism or directory for social worship, under the title of *Manuel des Theanthrophiles*. This religious breviary found favour: the congregation became numerous; and in the second edition of their manual they assumed the less harsh denomination of *Theophilanthropes, i. e* lovers of God and man. A book of hymns, a liturgy for every decade of the French year, and an homiletical selection of moral lessons, are announced or published, by their unknown synod. Thus they possess a system of pious services adapted to all occasions, which some one of the individuals who attend reads aloud; for they object to the employment of a regular lecturer, in consequence of their hostility to priests.— This novel sect was countenanced by Larevelliere Lepaux, one of the Directory, and, soon after its formation, opened temples of its own in Dijon, and in other provincial towns They had declamations, in the spirit of sermons, which abounded with such phrases as *l'eternal geometre*, and the like, and which have long since been familiar to those who frequent the lodges of free masonry. Whether the sect now exists, or fell at the last revolution which annihilated the directory, we have not learned; but a translation of its *Manuel* into English, for the use, we suppose, of our Jacobins, was made so early as the year 1797. From this contemptible performance, we learn that the creed of the Theophilanthropists is comprised in the four following propositions:

The Theophilanthropists believe in the existence of God, and the immortality of the soul.

The spectacle of the universe attests the existence of the First Being.

The faculty which we possess of thinking, assures us, that we have, within ourselves, a principle which is superior to matter, and which survives the dissolution of the body.

The existence of God, and the immortality of the soul, do not need long demonstrations; they are sentimental truths, which every one may find written in his heart, if he consult it with sincerity.

Thus a sort of religious instinct is set up as the sole foundation of piety, which every one has as much right to disavow as another to assert; and the obligations of which, therefore, can in no way be shewn to be incumbent on those to whom this novel illumination is not vouchsafed. Society, under such a system, gains no means of influencing the conduct of refractory members.

The morality of the Theophilanthropists is founded on one single precept: *Worship God, cherish your kind, render yourselves useful to your country!*

Among the duties comprehended under the denomination of cherishing our kind, we find that of *not lending for usury:* the others are chiefly extracted from the gospels, and do not interfere with the province of the civil magistrate. The question of monogamy is not discussed.

Among the duties to our country are placed those of fighting in its defence, and of paying the taxes. It was certainly prudent in the statesman to slide these duties into the catalogue of his established maxims of morality; and he ran thereby little risk of provoking heretical animadversions on his creed in France.

The following inscriptions are ordered to be placed above the altars in the several temples or synagogues of the Theophilanthropists; but for what reason altars are admitted into such synagogues we are not informed:

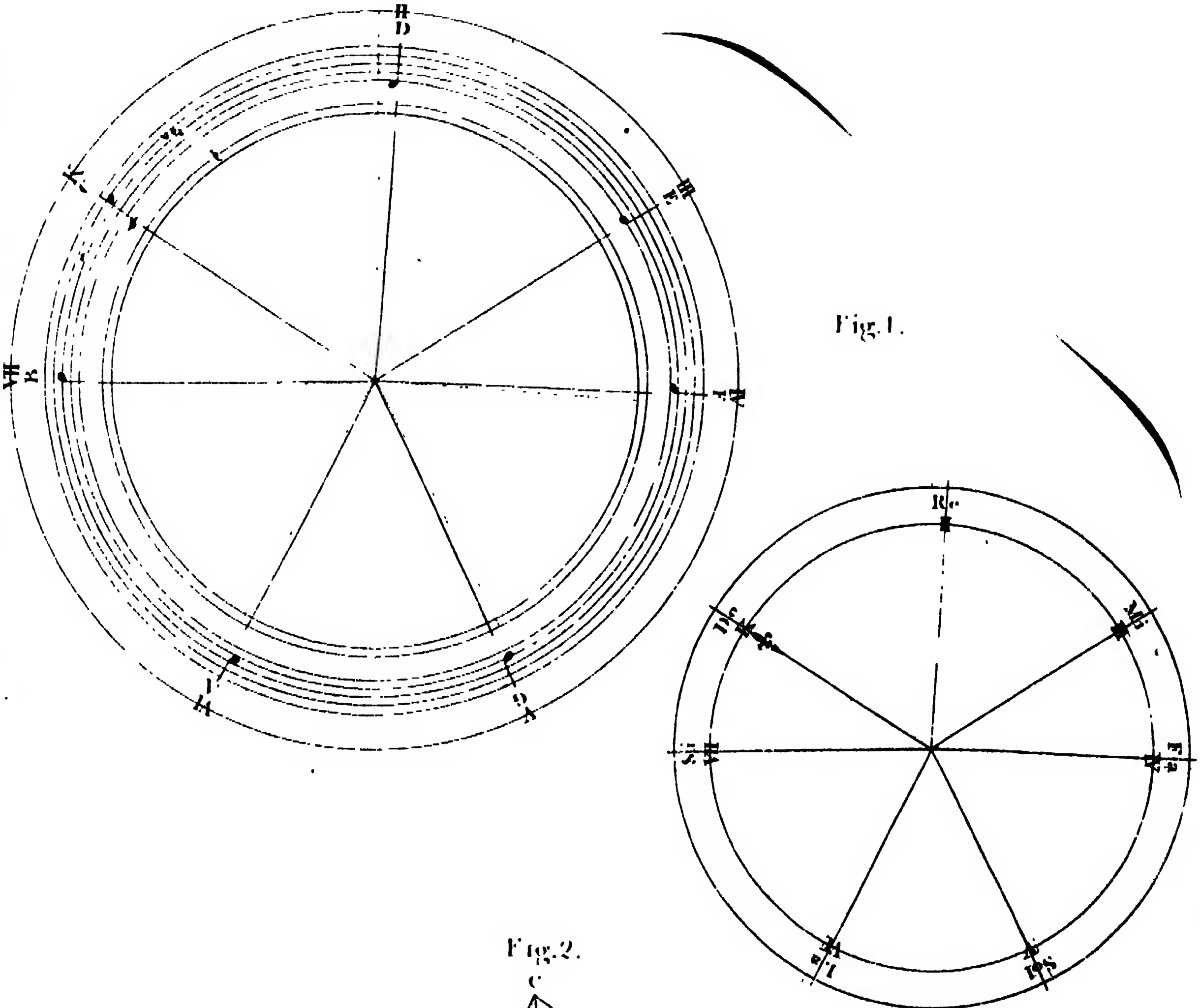
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Fig. 1.

Fig. 2.

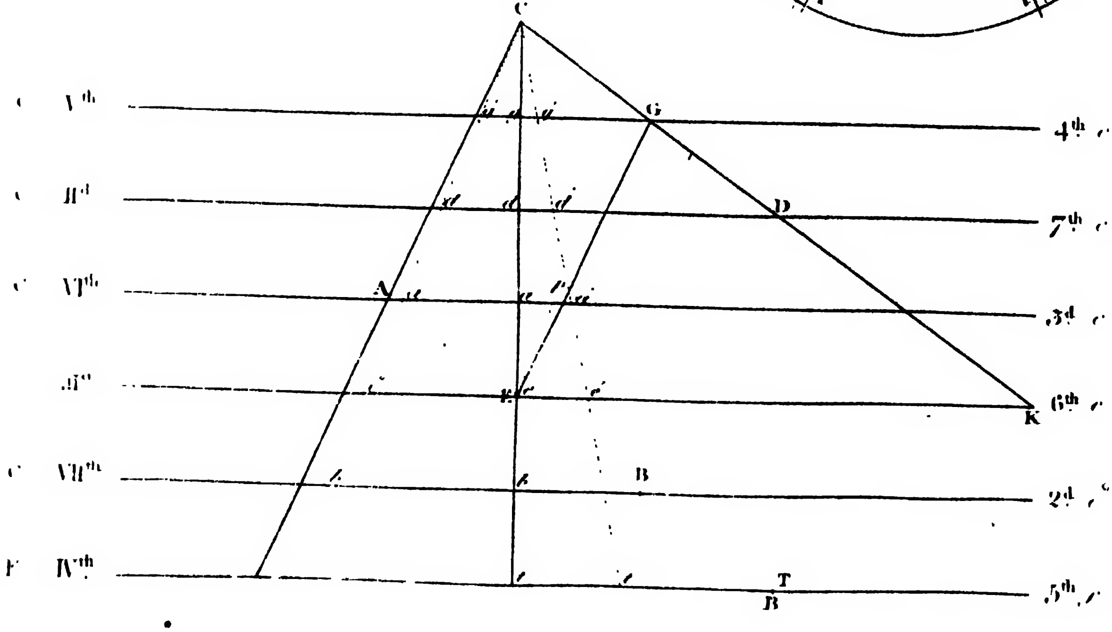
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Fig. 1.

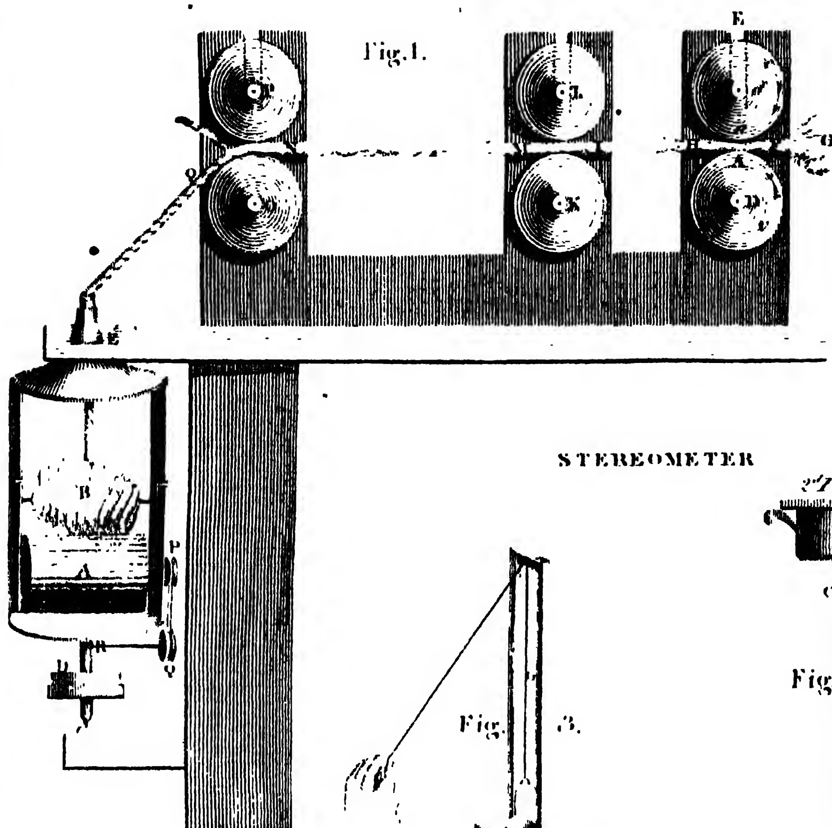
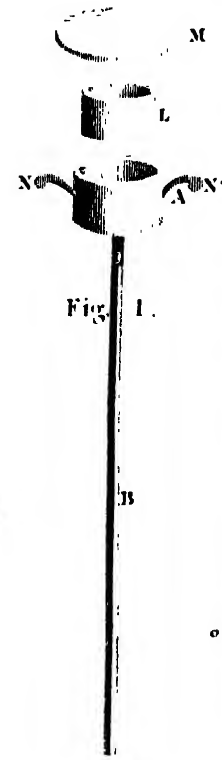


Fig. 1.



STEREOMETER

Fig. 3.

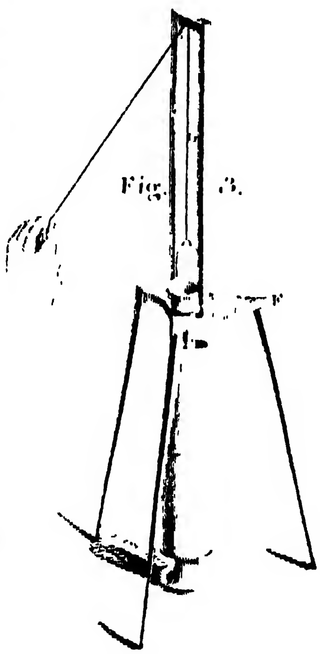
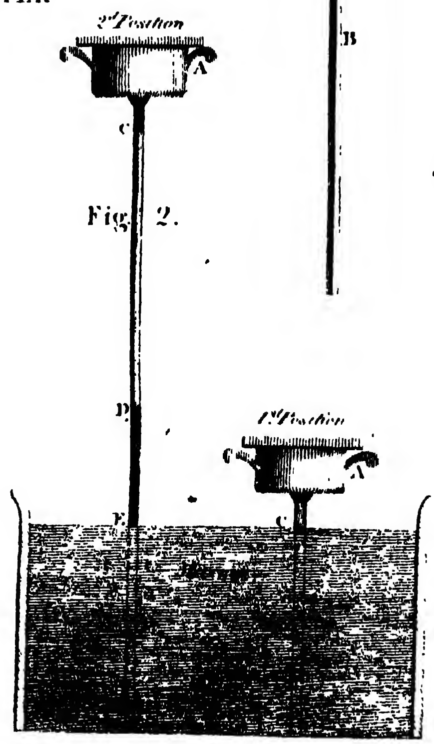


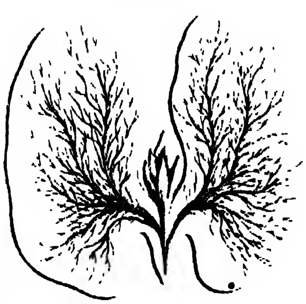
Fig. 2.



VEGETABLE SUBSTANCES

Fig 1.

Fig. 2.



TEREBRATULA

Fig. 1.

Fig. 2.

Theophilanthropists. Theophilus.

First inscription, "We believe in the Existence of God, in the immortality of the soul."

Second inscription. "Worship God, cherish your kind, render yourselves useful to the country."

Third inscription, "Good is every thing which tends to the preservation or the perfection of man.—Evil is every thing which tends to destroy or to deteriorate him."

Fourth inscription, "Children, honour your fathers and mothers. Obey them with affection. Comfort their old age.—Fathers and mothers, instruct your children."

Fifth inscription, "Wives, regard in your husbands the chiefs of your houses.—Husbands, love your wives, and render yourselves reciprocally happy."

This pentalogue is chiefly objectionable on account of the vague drift of the fifth commandment: the whole has too general a turn for obvious practical application. The introduction of ceremonies of sculpture, of painting, and of engraving, is forbidden. If poetry and music may concur to render the worship impressive, why not the other fine arts? The fine arts have never illustrated a country which excluded them from the public temples. Are they to be extinguished in France by Theophilanthropic iconoclasts?

At p. 78. of the Manuel, this surprising maxim occurs: *Avoid innovations!* A sect fifteen months old grown as testy as the church of Rome! They acknowledge, that perhaps better inscriptions may be found; yet they forbid the exchange. They prefer *mumpsimus* to the *sumpsimus* of genuine Christianity!

THEOPHILUS, a writer and bishop of the primitive church, was educated a Heathen, and afterwards converted to Christianity. Some have imagined that he is the person to whom St Luke dedicates the Acts of the Apostles; but they are grossly mistaken; for this Theophilus was so far from being contemporary with St Luke and the apostles, that he was not ordained bishop of Antioch till *anno* 170; and he governed this church twelve or thirteen years. He was a vigorous opposer of certain heretics of his time, and composed a great number of works; all of which are lost, except three books to Autolycus, a learned Heathen of his acquaintance, who had undertaken to vindicate his own religion against that of the Christians. The first book is properly a discourse between him and Autolycus, in answer to what this Heathen had said against Christianity. The second is to convince him of the falsehood of his own, and the truth of the Christian religion. In the third, after having proved that the writings of the Heathens are full of absurdities and contradictions, he vindicates the doctrine and the lives of the Christians from those false and scandalous imputations which were then brought against them. Lastly, at the end of his work, he adds an historical chronology from the beginning of the world to his own time, to prove that the history of Moses is at once the most ancient and the truest; and it appears from this little epitome, how well this author was acquainted with profane history. These three books are filled with a great variety of curious disquisitions concerning the opinions of the poets and philosophers, and there are but few things in them relating immediately to the doctrines of the Christian religion. Not that Theophilus was ignorant of these doctrines, but, having composed his works for the conversion of a Pagan, he insisted rather on the external evidence or proofs from without, as better adapted, in his opinion, to the purpose. His style is elegant, and the turn of his thoughts very agreeable; and this little specimen is sufficient to shew that he was indeed a very eloquent man.

. Dict.

The piece is intitled, in the Greek manuscripts, "The books of Theophilus to Autolycus, concerning the Faith of the Christians, against the malicious detractors of their religion." They were published, with a Latin version, by Conradus Gesner, at Zurich, in 1546. They were afterwards subjoined to Justin Martyr's works, printed at Paris in 1615 and 1636; then published at Oxford, 1684, in 12mo, under the inspection of Dr Fell; and, lastly, by Jo Christ. Wolfius, at Hamburgh, 1723, in 8vo.

It is remarkable, that this patriarch of Antioch was the first who applied the term *Trinity* to express the Three Persons in the Godhead.

Therapeutæ.

THERAPEUTÆ, so called from the extraordinary purity of their religious worship, were a Jewish sect, who, with a kind of religious phrenzy, placed their whole felicity in the contemplation of the Divine nature. Detaching themselves wholly from secular affairs, they transferred their property to their relations or friends, and withdrew into solitary places, where they devoted themselves to a holy life. The principal society of this kind was formed near Alexandria, where they lived, not far from each other, in separate cottages, each of which had its own sacred apartment, to which the inhabitant retired for the purposes of devotion. After their morning prayers, they spent the day in studying the law and the prophets, endeavouring, by the help of the commentaries of their ancestors, to discover some allegorical meaning in every part. Besides this, they entertained themselves with composing sacred hymns in various kinds of metre. Six days of the week were, in this manner, passed in solitude. On the seventh day they met, clothed in a decent habit, in a public assembly; where, taking their places according to their age, they sat, with the right hand between the breast and the chin, and the left at the side. Then some one of the elders, stepping forth into the middle of the assembly, discoursed, with a grave countenance and a calm of tone voice, on the doctrines of the sect; the audience, in the mean time, remaining in perfect silence, and occasionally expressing their attention and approbation by a nod. The chapel where they met was divided into two apartments; one for the men, the other for the women. So strict a regard was paid to silence in these assemblies, that no one was permitted to whisper, or even to breathe aloud; but when the discourse was finished, if the question which had been proposed for solution had been treated to the satisfaction of the audience, they expressed their approbation by a murmur of applause. Then the speaker, rising, sung a hymn of praise to God, in the last verse of w[illegible] whole assembly joined. On great festivals, the meeting was closed with a vigil, in which sacred music was performed, accompanyed with solemn dancing: and these vigils were continued till morning, when the assembly, after a morning prayer, in which their faces were directed towards the rising sun, was broken up. So abstemious were these ascetics, that they commonly ate nothing before the setting sun, and often fasted two or three

three days. They abstained from wine, and their ordinary food was bread and herbs.

Much dispute has arisen among the learned concerning this sect. Some have imagined them to have been Judaizing Gentiles; but Philo supposes them to be Jews, by speaking of them as a branch of the sect of Essenes, and expressly classes them among the followers of Moses. Others have maintained, that the Therapeutæ were an Alexandrian sect of Jewish converts to the Christian faith, who devoted themselves to a monastic life. But this is impossible; for Philo, who wrote before Christianity appeared in Egypt, speaks of this as an established sect. From comparing Philo's account of this sect with the state of philosophy in the country where it flourished, we conclude, that the Therapeutæ were a body of Jewish fanatics, who suffered themselves to be drawn aside from the simplicity of their ancient religion by the example of the Egyptians and Pythagoreans. How long this sect continued is uncertain; but it is not improbable that, after the appearance of Christianity in Egypt, it soon became extinct.

THERMOMETRIC SPECTRUM, is a name given to the space in which a thermometer may be placed, so that it shall be affected by the sun's rays refracted by a prism. It is, in part, the same with the PRISMATIC SPECTRUM, which exhibits the different colours produced by the solar light.

The philosophical instrument now called a *thermometer*, was first named THERMOSCOPE; and was prized by the naturalist, because it gave him indications of the presence and agency of fire in many cases where our sensation of warmth or heat was unable to discover it. It was not long before it was observed that it also affords us measures of the changes which take place either in the quantity or the activity of the cause of heat, and of many other important pheunomena usually accompanied by heat. They were then called *thermometers*. But in both of these offices, it is still a doubt whether it indicates and measures any real substance, a being *sui generis*, to which we may give the name *fire*, *phlogiston*, *caloric*, *heat*, or any other; or only indicates and measures certain states or conditions, in which all bodies may be found, without the addition or abstraction of any material substance.

We think that this question has a greater chance now of being decided than in any former time, in consequence of a recent and very important discovery made by that unwearied observer of the works of God, the celebrated Dr Herschel. Being greatly incommoded when looking at the sun, by the great heats produced in the eye-pieces of his telescopes, he thought that the laws of refraction enabled him to diminish them by a proper construction of his eye-pieces. He began his attempts like a philosopher, by examining the heat produced in the various parts of the prismatic spectrum. Comparing the gradation of heat with that of illumination, he found that they did not, by any means, follow the same law. The illumination increased gradually from the violet end of the spectrum, where it was exceedingly faint, to the boundary of the green and yellow, where it was the most remarkable; and after this, it decreased as the illuminated object approached the red extremity of the spectrum. But the calorific power of the refracted light increased all the way from the extreme violet to the extreme red; and its last augmentations were considerable, and therefore unlike the usual approaches of a quantity to its maximum state. This made him think of placing the thermometer a little way beyond the extremity of the visible spectrum. To his great astonishment, he found that the thermometer was more affected there than in the hottest part of the *illuminated* spectrum. Exposing the thermometer at various distances beyond the extreme red, but in the plane of refraction, he found that it was most strongly affected when placed beyond that extremity, about one-fifth of the whole length of the spectrum; from thence the calorific influence of the sun gradually diminished, but was still very considerable, at a distance from the extreme red equal to three fifths of the length of the luminous spectrum. These first suggested modes of trial appeared to Dr Herschel to be too rude to intitle him to say that the warming influence did not extend still farther. Indeed the instrument scarcely performed the part of a thermometer, but merely that of an indicator of heat, or a thermoscope.

Here is a very new, and wonderful, and important, piece of information. We apprehend that all the philosophers of Europe, as well as the unlearned of all nations, believe that the *warming* influence of the sun, and of other luminous bodies, is conjoined with their power of *illumination*. Most of the philosophers admitted the emission of a matter called *light*, projected from the shining body, and moving with astonishing velocity, in those lines which the mathematicians called *rays*, because they diverged from the shining point, as the *radii* or spokes of a wheel diverge from the nave. This notion seems to be the simple suggestion of Nature; and it also seems to be the opinion entertained by Sir Isaac Newton. His demonstration of the laws of reflection and refraction proceeds on this supposition alone, and the particles of light are held by him to be affected by accelerating and deflecting forces, in the same way as a stone thrown from the hand is affected by gravity. Huyghens, indeed, Dr Hooke, and Euler, imagined that vision and illumination were effected in the same way that hearing, and resonance, and echo, are effected—that there is no matter projected from the shining body; but that we are surrounded by an elastic fluid, which is thrown into vibrations by certain tremors of the visible object—and that those vibrations of this fluid affect our eye in the same way as the undulation of elastic air, produced by the tremors of a string or a bell, affect our ear. According to these philosophers, a ray of vision is merely the line which passes through all these undulations at right angles.

These two opinions still divide the mathematical philosophers of Europe; but the majority, and particularly the most eminent for mathematical and mechanical science, are (with the exception of Huyghens and Euler) on the side of the vulgar. This opinion has been greatly strengthened of late years by the discoveries in chemistry. The influence of light on the growth of plants, the total want of aromatic oils in such as grow in the dark, and their formation and appearance in the very same plant, along with the green colour, as soon as the plant is placed in the light (even that of open day without sunshine, or in the light of a candle), is a strong indication of some substance being obtained from the light, absorbed by the plant, and combined with its other ingredients. The same conclusion is drawn from the

the effects of the sun's light on vegetable colours, on the nitric and nitrous acids, on manganese, on the calces or oxyds of metals, and numberless other instances, which all concur in rendering it almost unquestionable that the sun's rays, and those of other shining bodies, may be, and daily are, combined with the other substances of which bodies are composed, and may be again separated from them. And, should any doubts remain, it would seem that the theory of combustion, first conceived and imperfectly published by Dr Hooke in his *Micrography*, p. 103. and in his *Lampas*, p. 1. &c. adopted by Mayow (see HOOKE and MAYOW in this *Suppl.*), forgotten, and lately revived and confirmed by Mr Lavoisier, removes them entirely. In the beautiful and well-contrived experiments of the last gentleman, the light, accompanied by its heat which had been absorbed in the process of growth or other natural operations, re-appeared in their primitive form, and might again be absorbed and made to undergo the same round of changes.

Scheele, not inferior to Newton in caution, patience, and accuracy, and attentive to every thing that occurred in his experiments, discovered the separability of the illuminating and the warming influences of shining bodies. He remarked, that a plate of glass, the most colourless and pellucid that can be procured, when suddenly interposed between a glowing fire and the face, instantly cuts off the warming power of the fire, without causing any sensible diminution of its brilliancy. He followed this discovery into many obvious consequences, and found them all fully confirmed by observation and experiment. The writer of this article, immediately on hearing of Scheele's experiments, repeated them with complete success: but he found, that when the glass plate had acquired the highest temperature which it could acquire in that situation, it did not any longer intercept the heat, or at least in a very small and almost insensible degree. It seemed to absorb the heat, till saturated, without absorbing any considerable portion of the light.

This separability of heat from light does not seem to have met with the attention it deserved. Dr Scheele's untenable theories on these subjects turned away the attention of the chemists from this discovery, and the mathematical philosophers seem not to have heard of it at all. The late Dr Hutton of Edinburgh was more sensible of its importance; and in his last endeavours to support the falling cause of phlogiston, makes frequent allusions to it. But in his attempts to explain the curious observations of Messrs Saussure and Pictet, in which there are unquestionable appearances of radiated heat, he reasons so unconsequentially, that few readers proceed farther, so as to notice several observations of facts where the illuminating and warming influences are plainly separated. In all these instances, however, Dr Hutton considers the invisible rays as light, but not as heat; maintaining that they are invisible, or do not render bodies visible, only because our eyes are insensible to their feeble action.

It was reserved for Dr Herschel to put this matter beyond dispute by these valuable experiments. For did the invisibility of any of the light beyond the extreme red of the prismatic spectrum arise from the insensibility of our organs, the spectrum would gradually fade away beyond the red; but it ceases abruptly. These thoughts could not escape this attentive observer. He therefore examined more particularly those invisible rays, causing them to be reflected by mirrors, and refracted through lenses; and, in short, he subjected them to all the subsequent treatments which Newton applied to the colouring rays. He found them retain their specific refrangibilities and reflexibilities with as much uniformity and obstinacy as Newton had observed in the colour-making rays. They were made to pass through lenses while the illuminating rays were intercepted by an opaque body, and the invisible rays were then collected into a focus. They were reflected, both by the anterior and posterior surfaces of transparent bodies. In all these trials they retained their power of expanding the liquor of a thermometer, and exciting the sensation of heat

Thermometric.

These trials were not confined to the solar light or the solar rays: They were also made on the emanations from a candle, from an open fire, and from red hot iron; then they were made with bodies not hot enough to shine; with the heat of a common stove, and the heat from iron which was not visible in the dark. The event was the same in all; and it was clearly proved that heat, or the cause of heat, is as susceptible of radiation as light is; and that this radiation is performed in both according to the same laws.

We look with impatience for the subsequent experiments of this celebrated philosopher on this subject; for we consider them as of the greatest and most extensive importance for explaining the operations of Nature. We see, with indisputable evidence, that there are rays from the sun, and other bodies, which do not illuminate. It does not follow, however, that there are rays which do not warm; for the thermometer was affected in every part of the coloured spectrum. Dr Herschel seems to think that the power of affecting the organ of sight depends on the particular degrees of mechanical momentum which are indicated by the different degrees of refrangibility. We confess that we think it unlikely that such a power should terminate abruptly. We do not observe this in analogous phenomena: the evanescence of our sensations of sound, of musical pitch, of heat, &c. are all gradual. We think it more likely that illuminating and warming are specific effects of different things. We should have entertained this opinion independent of all other experience; and we think it strongly confirmed by the experiments of Dr Scheele already mentioned. We are disposed therefore to believe that there are rays which illuminate, but which do not warm; and rays which warm without illuminating. We have experiments in prospect, by which we hope to put this to the test.

These experiments of Dr Herschel afford another good argument for the common opinion concerning light, namely, that *it is a matter emitted from the shining body*, and not merely the undulations of an elastic medium; for if it were undulation, then, since there is heat in the yellow light, it would follow that a certain frequency of undulation produces both the sensation of heat and the sensation of a yellow colour. In this case they should be inseparable.

This follows, in the strictest manner, from the principles or assumptions adopted by Euler in his mechanical theory of undulations. The chromatic differences in the rays of light are affirmed to arise entirely from the

the different frequencies of the ætherial undulations; and he endeavours to shew that these differences in frequency produce a difference in refrangibility. It is evident that this reasoning is equally conclusive with respect to the calorific or heating power of the rays. The light and the heat are both undulations: these differ only in frequency; and this frequency is indicated (according to Euler) by the refrangibility. There is a certain frequency therefore which excites the sensation of yellow. The same frequency, indicated by the same refrangibility, produces heat; therefore the frequency which produces this degree of heat also produces the sensation of yellow. We must not say that the momentum of the undulation may produce heat, but is insufficient for the production of light, as a string may vibrate too [illegible] for being heard: for we see, by Dr Herschel's experiments, that, with a momentum sufficient for making the most brilliant spectrum, there are rays (and those which have the greatest momentum) which produce heat, and yet are invisible.

It does not follow, from any of Dr Herschel's experiments, that the rays emitted by iron, which is not hot enough to shine in a dark room, have *all* the different degrees of refrangibility observed by him. Perhaps none of them would fall on the chromatic spectrum. We think, however, that this is not probable. It may be tried by collecting them to a focus by a lense, intercepting, however, all those which are less refrangible than the red making rays. We trust that the thermometer in the focus will still be affected.

This is but a very imperfect account of this important discovery: but we thought that it would be highly interesting to our readers. The press was employed on this very sheet when we received the information from a friend, who had seen Dr Herschel's Dissertation, which will appear in the first volume published by the Royal Society. We trust that the ingenious author will soon follow it up with the investigation of the subject in all its consequences.

We hope that he will examine what will result from mixing some of the invisible rays with some of the coloured ones. We know that the yellow and the blue, when mixed, produce the sensation of green. Perhaps the invisible rays may also change the appearance. We do not, however, expect this.

We also hope that Dr Herschel will examine whether the invisible rays of the sun produce any effect on vegetable colours; whether they blacken the calces of silver and bismuth, luna cornea, and decompose the nitrous and the oxygenated muriatic acid, &c. &c. We should thus get more insight into the nature of caloric and of combustion. Combustion may perhaps be restored to its rank in the phenomena of Nature, and no longer be sunk in the general gulph of oxygenation, and thus obliterated from the memory of chemists. It is perhaps the most remarkable phenomenon of material Nature; and *fire* and burning will never go out of the language of plain men. Fire, and all its concomitants, have, in all times, been considered as even the *chief* objects of chemical attention; and an unlearned person will stare, when a chemist tells him that there is no such thing, and that what he calls the burning of a piece of coal is only the making it sour. He will perhaps smile; but it will not be a smile of assent.

It was one darling object of the Revolutionary Committee of Chemists, assembled at Paris in 1787, to banish from our minds, *by means of a new language*, all remembrance of any thing which we did not derive from the philosophers of France. We think ourselves in a condition to prove this by letters to this country from the scene of action; in which the expected victory is spoken of in terms of exultation, and with so little restraint, that the writer forgets that it is Dr Black whom he is informing that *l'air fixe* and *la pauvre phlogistique* will soon be forgotten; and yet the writer was a gentleman of uncommon modesty and worth, and sincerely attached to Dr Black. We give this as a remarkable instance of the *esprit de corps*, and of the nature and towering ambition of that nation. From this they have not swerved; and they hope to gain this summit of scientific dominion in the same way as *the same philosophers* hope to banish Christianity by means of their new kalendar. It may, however, turn out that both Dr Hooke and Mr Lavoisier are mistaken, when they make the oxygen gas the sole source of both the light and the heat which accompany combustion. One of them may perhaps be furnished by the body which all, except the new philosophers, call combustible.

Thermometric

The objections which may be made to the theory of Huyghens and Euler, on the acknowledged principles of mechanics, appear to us unanswerable. Euler has never attempted to answer those taken from the different dispersing powers of different substances. The objections made to the Newtonian, or vulgar theory of emission, are not such as imply absurdity; they are only difficulties. The chief of them, *viz.* the sameness of velocity in all lights whatever, is of this kind. It is merely an improbability. But the objections to the theory of undulation, deduced from the chemical effects of light, are not less strong than those deduced from mechanical principles. It is quite inconceivable that the undulation of a medium, which pervades all bodies, shall produce aromatic oils in some, a green fæcula in others, shall change sulphuric acid into sulphur, &c. &c. No effects are produced by the undulations of air, or the tremors of elastic bodies, which have the most distant analogy or resemblance to these.

That the sun and other shining bodies emit the matter of light and heat, seems therefore to merit the general reception which it meets with from the philosophers. But even of this class there are differences in opinion. Some imagine that light only is emitted, and that the heat which we feel is occasioned by the action of the luminous rays on our atmosphere, or on the ground. Were the sun's calorific rays as dense at the surface of the sun as his luminous rays are, the heat there must exceed (say they) all that we can form any conception of. Yet we see, that when the nucleus of the sun is laid bare by some natural operation, which, like a volcanic explosion, throws aside the luminous ocean which covers it to a prodigious depth, the naked parts of this nucleus are black. Therefore the intense heat in that place is not able to make it shining hot, as it does in all our experiments with intense heats, giving a dazzling glare. This is thought highly improbable; and it is therefore supposed that there is, primitively, no heat in the sun's rays, but that they act on our air, or other terrestrial matter, combining with it, and disengaging heat from it, or producing that particular state and condition which we call *heat*.

We think that Dr Herschel's discovery militates strongly and irresistibly against this opinion; and shews, that

that whatever reason we have for saying that the sun's rays bring light from the sun we have the same authority for saying, that they bring heat, fire, caloric, phlogiston, or by whatever other name we choose to distinguish the cause of warmth, expansion, liquefaction, ebullition, &c.

We must either say that light and heat are not substances of a peculiar kind, susceptible of union with the other ingredients of bodies, but merely a state of undulation of an elastic medium, as sound is the undulation of air; or we must say that the sun's rays contain light and heat, in a detached state, fit for appearing in their simplest form, producing illumination and expansion, and for uniting chemically with other matter. Whichever of these opinions we adopt, it is pretty clear that all attempts to discover a difference in the weight of hot and cold bodies may be given over. In the first case, it is self-evident; in the second, we have abundant evidence, that if light and heat, being gravitating matter, like all other bodies, were added to, or abstracted from bodies, in sufficient quantity to be sensibly heavy, the rays of the sun, or even the light of a candle, would occasion instant destruction by its mere momentum; since every particle of radiated light and heat moves at the rate of 200,000 miles in a second.

This discovery of Dr Herschel's adds greatly to the probability of the opinion which we expressed on another occasion, that the forces or powers of natural substances, which are the immediate causes of the chemical phenomena, are no way different from the mechanical forces which render bodies heavy, coherent, elastic, expansive, &c.; in short, that they are what we call *accelerating forces*. We deduced this from the fact, that mechanical force can be opposed to them, so as to prevent their action in circumstances where it would otherwise certainly take place. Thus, by external pressure, we can prevent that union of water and caloric which would convert it into elastic steam. We can even disunite them again, when steam is already produced, by forcibly condensing it into a smaller space. Now, the refraction and reflection of heat are performed according to the same precise laws which we observe in the refraction and reflection of light; and Sir Isaac Newton has demonstrated that those phenomena arise from the action of accelerating forces, whose direction is perpendicular to the acting surfaces. The matter of heat, therefore, is like other matter in its mechanical properties; and, in the motion of refraction, it is acted on and deflected, just as a projectile is acted on and deflected by gravity. It continues in motion till its velocity and direction are changed by deflecting forces, exerted by the particles of the transparent medium or the reflecting surface. It would take up too much room, but it is a very easy process, to demonstrate that this regular refraction of heat is altogether incompatible with the usually supposed notion of caloric; namely, that it is an expansive fluid like air, but incomparably more elastic: from which property very plausible explanations have been given of the elasticity of gases, steams, and such like fluids. Every intelligent mechanician will be sensible, that all this sort of chemical science falls to the ground, when it is proved, by exhibition of the fact, that radiated heat is refracted in the same way with radiated light. We must look for the explanation of the immense explosive force of fulminating silver, gold, &c. in some very different principles from those which are now in vogue. We apprehend, too, that the very phenomenon of this refraction gives indication of forces which are sufficiently powerful for this explanation: For when we reflect on the astonishing velocity of the ray of heat; on the minute space along which it is deflected, and consequently the time of this action, minute beyond all imagination; and when we compare these circumstances with the deflection produced by gravity in the motion of a projectile — it is evident that the deflecting force of refraction must exceed the greatest force that we have any knowledge of, in a greater proportion than the weight of Mount Ætna exceeds that of a particle of sand. We would desire Mr de la Place to suspend his hopes of establishing universal fatalism, till he can reconcile these phenomena with his fundamental " *that all forces which are diffused from a single point, necessarily and essentially diminish in the inverse duplicate ratio of the distances.*" Till he can do this, he had better still allow, with Newton, that the selection of the duplicate ratio for the action of gravity (by which alone the solar system can be rendered permanent and orderly) is a mark of wisdom and benevolence. We would advise him to reconcile his mind to this; and perhaps, like the modest and admiring Newton, he may, in good time, find comfort in the thought.

It is also highly worthy of remark, that this refracting force, almost immense, which is so plainly exerted between the particles of bodies and light, when considered as of the same kind with those that produce chemical union, appears abundantly sufficient for explaining some of the most wonderful phenomena of chemistry; such as the prodigious elasticity of steam, of gunpowder, and the still more astonishing explosion of fulminating gold and silver. Some of the phenomena of deflected light are produced by these optical forces acting at distances sufficiently great to admit of measurement; as in the Newtonian observations on the passage of light near the edges of opaque bodies. These deflections enable us to compare the deflecting forces with gravity. The *refracting* force, however, is vastly greater than even this, as may be seen by the greater deflection which is produced by it; and, being exerted along a space incomparably smaller, it must be greater still. Here, then, are forces fully adequate to the phenomena of fulmination. And we would again desire Mr De la Place to remark that, although these exploding forces are irresistible, their action seems to vanish entirely beyond the limits of mathematical contact. This is plain from the fact, that those explosions do not project the fragments to great distances. This is remarkably the case in all the most eminent of them. Common or nitric gunpowder is perhaps the only great exception. This particular circumstance will surely suggest to this eminent analyst the *inverse triplicate* ratio of the distance as more likely to explain the phenomena than his favourite law.

We trust that our readers will not be displeased with this short sketch of Dr Herschel's discovery, and the few reflections which it naturally suggested to our minds. We shall not be greatly surprised, although it should produce a sort of counter revolution in chemical science, in consequence of new conceptions which it may give us of the union of bodies with light and heat. The phenomena of the vegetable and animal economy

Thevenot, Thomas.

that they are susceptible of combination with other substances besides the basis of vital air. Whatever changes this may produce in the great revolution which has already taken place in chemical science, they will (in our opinion) be favourable to true philosophy; because Dr Herschel's discovery co-operates with other arguments of sound mathematical reasoning, to overturn that principle on which De la Place hopes to found his atheistical doctrine of fate and necessity. It contributes therefore to restore to the face of Nature that smiling feature of providential WISDOM which Newton had the honour of exhibiting to the view of rational men. The sun is the source of light and genial warmth to a vast system, which is held together, in almost eternal order and beauty, by a law of attraction selected by Infinite Wisdom, as the only one adequate to this magnificent purpose.

THEVENOT (Melchisedec), librarian to the king of France, and a celebrated writer of travels, was born at Paris in 1621, and had scarcely gone through his academical studies, when he discovered a strong passion for visiting foreign countries. At first he saw only part of Europe; but then he took great care to procure very particular informations and memoirs from those who had travelled over other parts of the globe, and out of those composed his "Voyages and Travels."—He laid down, among other things, some rules, together with the invention of an instrument, for the better finding out of the longitude, and the declination of the needle; and some have thought that these are the best things in his works, since travels, related at second-hand, can never be thought of any great authority or moment; not but Thevenot travelled enough to relate some things upon his own knowledge. Another passion in him, equally strong with that for travelling, was to collect scarce books in all sciences, especially in philosophy, mathematics, and history; and in this he may be said to have spent his whole life. When he had the care of the King's library, though it was one of the best furnished in Europe, he found 2000 volumes wanting in it which he had in his own. Besides printed books, he bought a great many manuscripts in French, English, Spanish, Italian, Latin, Greek, Hebrew, Syriac, Arabic, Turkish, and Persic. The marbles presented to him by Mr Nointel, at his return from his embassy to Constantinople, upon which there are bas-reliefs and inscriptions almost 2000 years old, may be reckoned among the curiosities of his library. He spent most of his time among his books, without aiming at any post of figure or profit; he had, however, two honourable employments; for he assisted at a conclave held after the death of Pope Innocent X and was the French king's envoy at Genoa. He was attacked with what is called a slow fever in 1692, and died October the same year, at the age of 71. According to the account given, he managed himself very improperly in this illness; for he diminished his strength by abstinence, while he should have increased it with hearty food and generous wines, which were yet the more necessary on account of his great age.—Thevenot's Travels into the Levant, &c. were published in English in the year 1687, folio; they had been published in French at Paris 1663, folio. He wrote also "L'Art de Nager," the Art of Swimming, 12mo, 1696.

THOMAS (Christian) was born at Leipsic 1655, and was well educated, first under his father, and afterwards in the Leipsic university. At first he acquiesced in the established doctrines of the schools; but upon reading Puffendorf's "Apology for rejecting the Scholastic Principles of Morals and Law," light suddenly burst upon his mind, and he determined to renounce all implicit deference to ancient dogmas. He read lectures upon the subject of Natural Law, first from the text of Grotius, and afterwards from that of Puffendorf, freely exercising his own judgment, and, where he saw reason, advancing new opinions. Whilst his father was living, paternal prudence and moderation restrained the natural vehemence and acrimony of the young man's temper, which was too apt to break out, even in his public lectures. But when he was left to himself, the boldness with which he advanced unpopular tenets, and the severity with which he dealt out his satirical censures, soon brought upon him the violent resentment of theologians and professors.

An "Introduction to Puffendorf," which Thomas published in the year 1687, wherein he deduced the obligation of morality from natural principles, occasioned great offence. The following year he became still more unpopular, by opening a monthly literary journal, which he intitled "Free Thoughts, or Monthly Dialogues on various Books, chiefly new;" in which he attacked many of his contemporaries with great severity. The raillery of this satirical work was too provoking to be endured: complaints were lodged before the ecclesiastical court of Dresden; the bookseller was called upon to give up the author; and it was only through the interest of the Mareschal that Thomas escaped punishment. The title of the work was now changed; but its spirit remained. A humorous and satirical life of Aristotle, and several other sarcastic papers, kept alive the flame of resentment, till at length it again burst forth, on a charge brought against him before the same court by the clergy of Leipsic, for contempt of religion; but he defended himself with such ability, that none of his adversaries chose to reply, and the matter was dropped.

A satirical review, which he wrote, of a treatise "On the Divine Right of Kings," published by a Danish divine; "A Defence of the Sect of the Pietists," and other eccentric and satirical publications, at last inflamed the resentment of the clergy against Thomas to such a degree, that he was threatened with imprisonment. To escape the storm which thickened about him, he entreated permission from the Elector of Brandenburg, in whose court he had several friends, that he might read private lectures in the city of Hall. This indulgence being obtained, Thomas became a voluntary exile from Leipsic. After a short interval, he was appointed public professor of jurisprudence, first in Berlin, and afterwards at Hall. In these situations, he found himself at full liberty to indulge his satirical humour, and to engage in the controversies of the times: and as long as he lived, he continued to make use of this liberty in a manner which subjected him to much odium.' At the same time, he persevered in his endeavours to correct and subdue the prejudices of mankind, and to improve the state of philosophy. He died at Hall in the year 1728.

Besides the satirical journal already mentioned, Thomas wrote several treatises on logic, morals, and jurisprudence; in which he advanced many dogmas contra-

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Thomas, Thornton.

ry to received opinions. In his writings on physics, he leaves the ground of experiment and rational investigation, and appears among the mystics. His later pieces are in many particulars inconsistent with the former.—His principal philosophical works are, "An Introduction to Aulic Philosophy, or Outlines of the Art of Thinking and Reasoning;" "Introduction to Rational Philosophy;" "A Logical Praxis;" "Introduction to Moral Philosophy;" "A Cure for Irregular Passions, and the Doctrine of Self-Knowledge;" "The new Art of discovering the secret Thoughts of Men;" "Divine Jurisprudence;" "Foundations of the Law of Nature and Nations;" "Dissertation on the Crime of Magic;" "Essay on the Nature and Essence of Spirit, or Principles of Natural and Moral Science;" "History of Wisdom and Folly."

From the specimen given by Dr Enfield of his more peculiar tenets (for we have read none of his books), Thomas appears to have been a man of wonderful inconsistency in his opinions; teaching on one subject rational piety and true science, and on another absurdity and atheism. "No other rule (he says) is necessary in reasoning, than that of following the natural order of investigation; beginning with those things which are best known, and proceeding, by easy steps, to those which are more difficult." This is perfectly consistent with the foundation of the Baconian logic; and is indeed the only foundation upon which a system of science can possibly be built. Yet could the man, who professes to proceed from a principle so well established, gravely advance, as conclusions of science, the following absurdities: "Perception is a passive affection, produced by some external object, either in the intellectual sense, or in the inclination of the will. God is not perceived by the intellectual sense, but by the inclination of the will: for creatures affect the brain; but God, the heart. All creatures are in God: nothing is exterior to him. Creation is extension produced from nothing by the divine power. Creatures are of two kinds, passive and active; the former is matter, the latter spirit. Matter is dark and cold, and capable of being acted upon by spirit, which is light, warm, and active. Spirit may subsist without matter, but desires a union with it. All bodies consist of matter and spirit, and have therefore some kind of life. Spirit attracts spirit, and thus sensibly operates upon matter united to spirit. This attraction in man is called *love*; in other bodies, *sympathy*. A finite spirit may be considered as a limited sphere, in which rays, luminous, warm, and active, flow from a centre. Spirit is the region of the body to which it is united. The region of finite spirits is God. The human soul is a ray from the divine nature; whence it desires union with God, who is love. Since the essence of spirit consists in action, and of body in passion, spirit may exist without thought: of this kind are light, ether, and other active principles in nature." Fortunately, this jargon is as unintelligible as the categories of Kant, and the blasphemies of Spinoza; for an account of which, the reader is referred to *Critical* PHILOSOPHY in this *Suppl.* and to SPINOZA in the *Encycl.*

Biographical Dictionary

THORNTON (Bonnel), a modern poet, the intimate friend of Lloyd and Colman, and justly classed with them in point of talents, was born in Maiden-lane, London, in the year 1724. He was the son of an apothecary; and being educated at Westminster school, was elected to Christ Church, Oxford, in the year 1743. He was thus eight years senior to Colman, who was elected off in 1751. The first publication in which he was concerned was, "The Student, or Oxford and Cambridge Miscellany," which appeared in monthly numbers; and was collected in two volumes 8vo, in 1748. Smart was the chief conductor of the work; but Thornton, and other wits of both universities, assisted in it. He took his degree of master of arts in 1750; and as his father wished him to make physic his profession, he took the degree of bachelor of that faculty in 1754. In the same year he undertook the periodical paper called *The Connoisseur*, in conjunction with Colman, which they continued weekly to the 30th of September 1756. In the concluding paper, the different ages and pursuits of the two authors are thus jocularly pointed out, in the description of the double author, Mr Town. "Mr Town is a fair, black, middle-sized, very short man. He wears his own hair and a periwig. He is about thirty years of age (literally thirty two), and not more than four-and-twenty. He is a student of the law and a bachelor of physic. He was bred at the university of Oxford, where, having taken no less than three degrees, he looks down on many learned professors as his inferiors: yet having been there but little longer than to take the first degree of bachelor of arts, it has more than once happened that the censor-general of all England has been reprimanded by the censor of his college, for neglecting to furnish the usual essay, or, in the collegiate phrase, the theme of the week." Engaged in pursuits of this kind, Bonnel Thornton did not very closely follow the profession to which his father destined him, but lived rather a literary life, employing his pen on various subjects. To the daily paper called the *Public Advertiser*, then in high reputation, he was a frequent contributor; and he once had it in contemplation to treat with Mr Rich for the patent of Covent Garden theatre. In 1764, Mr Thornton married Miss Sylvia Brathwaite, youngest daughter of Colonel Brathwaite, who had been governor of a fort in Africa. In 1766, encouraged, as he says himself, by the success of his friend Colman's Terence, he published two volumes of a translation of Plautus in blank verse; proposing to complete the whole if that specimen should be approved. These volumes contained seven plays, of which the *Captive* was translated by Mr Warner, who afterwards completed all that Thornton had left unfinished; and the *Mercator* by Mr Colman. The remaining five are, the *Amphitryon*, *Miles Gloriosus*, *Trinummus*, *Aulularia*, *Rudens*. Some parts of the remaining plays which Thornton had translated are preserved by his continuator. There can be no doubt that this is the best way of translating the old comedies, and that Thornton was well qualified for the task; but the work has never been in high favour with the public. Yet Warburton said of it, that "he never read so just a translation, in so pure and elegant a style." Thornton published in 1767, *The Battle of the Wigs*, as an additional canto to Garth's Dispensary; the subject of which was the disputes then subsisting between the fellows and licentiates.

The life of Thornton was not destined to attain any great extension: in the prime of his days, while he was surrounded by domestic felicity, the comforts of fortune,

tune, and the reſpect of ſociety, ill health came upon him; and medical aid proving inefficient, he died, of the gout in his ſtomach, May 9. 1768, at only 44 years of age. His wife, a daughter, and two ſons, ſurvived him. Beſides the productions already mentioned, he wrote the papers in the Adventurer marked A; "An Ode to St Cecilia's day, adapted to the ancient British Muſic," a burleſque performance; "The Oxford Barber;" with many detached eſſays in the public papers. A few letters addreſſed to his Sylvia before they were married, diſplay great tenderneſs, expreſſed with frankneſs and eaſe. A ſmall edition of his works might, with much propriety, be preſented to the public, before it ſhall be too late to aſcertain them all. His character may be taken from his epitaph, written in Latin by his friend Dr Warton, and placed on his monument in Weſtminſter Abbey. It is to this effect: "His genius, cultivated moſt happily by every kind of polite literature, was accompanied and recommended by manners open, ſincere, and candid. In his writings and converſation he had a wonderful livelineſs, with a vein of pleaſantry peculiarly his own. In ridiculing the failings of men, without bitterneſs, and with much humour, he was ſingularly happy; as a companion, he was delightful."

THUNDER. There is not one of the appearances of nature which has ſo much engaged the attention of mankind as thunder. The ſavage, the citizen, and the philoſopher, have obſerved it with dread, with anxiety, and with curioſity; and the philoſopher of our times treats the others with a ſmile of condeſcenſion, while he here enjoys the fulleſt triumph of his ſuperiority.

> *Felix qui potuit rerum cognoſcere cauſas,*
> *Atque metus omnes et inevitabile fulmen*
> *Subjecit pedibus.*

But though this grand phenomenon has long engaged the curious attention of philoſophers, it is but very lately that they have been able to explain it; that is, to point out the more general law of nature of which it is a particular inſtance. Inflammable vapours had long furniſhed them with a ſort of explanation. The diſcovery of gunpowder, and ſtill more that of inflammable air, gave ſome probability to the exiſtence of extenſive ſtrata of inflammable vapours in the upper regions of the atmoſphere, which, being ſet on fire at one end, might burn away in rapid ſucceſſion, like a train of gunpowder. But the ſmalleſt inveſtigation would ſhew ſuch a diſſimilarity in the phenomena, and in the general effects, that this explanation can have no value in the eyes of a true naturaliſt. Horrid exploſion, and a blaſt which would ſweep every thing from the ſurface of the earth, muſt be the effects of ſuch inflammation. The very limited and capricious nature of the ravages made by thunder, render them altogether unlike exploſions of elaſtic fluids.

No ſooner were the wonderful effects of the charged electrical phial obſerved, than naturaliſts began to think of this as exhibiting ſome reſemblance to a thunderſtroke (ſee ELECTRICITY, *Encycl.* nº 12); but it was not till toward the year 1750 that this reſemblance was viewed in a proper light by the celebrated Franklin. In a diſſertation written that year, he delivers his opinion at large, and notices particularly the following circumſtances of ſimilarity.

Thunder, in ſeveral remarkable particulars.

1. The colour and crooked form of lightning, perfectly ſimilar to that of a vivid electrical ſpark between diſtant bodies, and unlike every other appearance of light. This angular, deſultory, capricious form of an electrical ſpark, and of forked lightning, is very ſingular. No two ſucceſſive ſparks have the ſame form. Their ſharp angles are unlike every appearance of motion through unreſiſting air. Such motions are always curvilineal. The ſpark is like the ſimultaneous exiſtence of the light in all its parts; and the fact is, that no perſon can poſitively ſay in which direction it moves.

2. Lightning, like electricity, always ſtrikes the moſt advanced objects—hills, trees, ſteeples.

3. Lightning affects to take the beſt conductors of electricity. Bell wires are very frequently deſtroyed by it. At Leven houſe in Fifeſhire, in 1733, it ran along a gilded moulding from one end of the houſe to the other, exploding it all the way, as alſo the tinfoil on the backs of ſeveral mirrors, and the gilding of ſcreens and leather hangings.

4. It burns, explodes, and deſtroys theſe conductors preciſely as electricity does. It diſſolves metals; melts wires; it explodes and tears to pieces bodies which contain moiſture. When a perſon is killed by lightning, his ſhoes are commonly burſt. When it falls on a wet ſurface, it ſpreads along it. The Royal William, in Louiſburgh harbour, in 1758, received a thunderſtroke, which diſſipated the maintop-gallant maſt in duſt, and came down on the wet decks in one ſpark, which ſpread over the whole deck as a ſpout of water would have done. This is quite according to electrical laws.

5. It has ſometimes ſtruck a perſon blind. Electricity has done the ſame to a chicken which it did not kill.

6. It affects the nervous ſyſtem in a way reſembling ſome of the known effects of electricity. The following is a moſt remarkable inſtance: —— Campbell, Eſq; of Succoth, in Dunbartonſhire, had been blind for ſeveral years. The diſorder was a gutta ſerena. He was led one evening along the ſtreets of Glaſgow by his ſervant Alexander Dick, during a terrible thunder ſtorm. The lightning ſometimes fluttered along the ſtreets for a quarter of a minute without ceaſing. While this fluttering laſted, Mr Campbell ſaw the ſtreet diſtinctly, and the changes which had been made in that part by taking down one of the city gates. When the ſtorm was over, his entire blindneſs returned.—We have from a friend another inſtance, no leſs remarkable. One evening in autumn he was ſitting with a gentleman who had the ſame diſorder, and he obſerved ſeveral lambent flaſhes of lightning. Their faces were turned to the parlour window; and immediately after a flaſh, the gentleman ſaid to his wife "Go, my dear, make them ſhut the white gate; it is open, you ſee." The lady did ſo, and returned; and, after a little, ſaid, "But how did you know that the gate was open?" He exclaimed, "My God! I ſaw it open, and two men look in, and go away again," (which our friend alſo had obſerved). The gentleman, on being cloſe queſtioned, could not recollect having had another glance, nor why it had not ſurpriſed him; but of the glimpſe itſelf he was certain, and deſcribed the appearance very exactly.

7. Lightning kills; and the appearances perfectly reſemble

reſemble thoſe of a mortal ſtroke of electricity. The muſcles are all in a ſtate of perfect relaxation, even in thoſe ſituations where it is uſually otherwiſe

8 Lightning is well known to deſtroy and to change the polarity of the mariner's needle.

Dr Franklin was not contented with the bare obſervation of theſe important reſemblances. He availed himſelf of many curious diſcoveries which he had made of electrical laws. In particular, having obſerved that electricity was drawn off at a great diſtance, and without the leaſt violence of action, by a ſharp metallic point, he propoſed to philoſophers to erect a tall maſt or pole on the higheſt part of a building, and to furniſh the top of it with a fine metalline point, properly inſulated, with a wire leading to an inſulated apparatus for exhibiting the common electrical appearances. To the whole of this contrivance he gave the name of *thunder-rod*, which it ſtill retains. He had not a proper opportunity of doing this himſelf at the time of writing his diſſertation in a letter from Philadelphia to the Royal Society of London; but the contents were ſo ſcientific, and ſo intereſting, that in a few weeks time they were known over all Europe. His directions were followed in many places. In particular, the French academicians, encouraged by the preſence of their monarch, and the great ſatiſfaction which he expreſſed at the repetition of Dr Franklin's moſt inſtructive experiments, which diſcovered and eſtabliſhed the theory of poſitive and negative electricity, as it is ſtill received, were eager to execute his orders, making his grand experiment, which promiſed ſo fairly to bring this tremendous operation of nature not only within the pale of ſcience, but within the management of human power.

But, in the mean time, Dr Franklin, impatient of delay, and perhaps incited by the honourable deſire of well-deſerved fame, put his own ſcheme in practice. His inventive mind ſuggeſted to him a moſt ingenious method of preſenting a point to a thunder cloud at a very great diſtance from the ground. This was by fixing his point on the head of a paper kite, which the wind ſhould raiſe to the clouds, while the wet ſtring that held it ſhould ſerve for a conductor of the electricity. We preſume that it was with a palpitating heart that Dr Franklin, unknown to the neighbours, and accompanied only by his ſon, went into the fields, and ſent up his meſſenger that was to bring him ſuch news from the heavens. He told a perſon, who repeated it in the hearing of the preſent writer, that when he ſaw the fibres of the cord raiſe themſelves up like hogs briſtles, he uttered a deep ſigh, and would have wiſhed that moment of joy to have been his laſt. He obtained but a few faint ſparks from his apparatus that day; but returned to his houſe in a ſtate of perfect happineſs, now feeling that his name was never to die. Thus did the ſoap-bubble, and the paper kite, from being the playthings of children, become, in the hands of Newton, and of Franklin, the means of acquiring immortal honour, and of doing the moſt important ſervice to ſociety.

We may juſtly conſider this as one of the greateſt of philoſophical diſcoveries, and as doing the higheſt honour to the inventor; for it was not a ſuggeſtion from an accidental obſervation, but aroſe from a ſcientific compariſon of facts, and a ſagacious application of the doctrine of poſitive and negative electricity; a doctrine wholly Dr Franklin's and the reſult of the moſt acute and diſcriminating obſervation. It was this alone that ſuggeſted the whole; and by explaining to his ſatisfaction the curious property of ſharp points, gave him the courage to handle the thunderbolt of Jove.

Thunder.

It is then a point fully aſcertained, that thunder and lightning are the electric ſnap and ſpark, as much ſuperior to our puny imitations as we can conceive from the immenſe extent of the inſtruments in the hands of Nature. If, ſays Dr Franklin, a conductor one foot thick and five feet long will produce ſuch ſnaps as agitate the whole human frame, what may we not expect from a ſurface of 10,000 acres of electrified clouds? How loud muſt be the exploſion? how terrible the effects?

Electrical ſtate of the air.

This diſcovery immediately directed the attention of philoſophers to the ſtate of the atmoſphere with reſpect to electricity; and in this alſo Dr Franklin led the way. He immediately erected his thunder rods; and they have been imitated all over the world, with many alterations or improvements, according to the different views and ſkill of their authors. It is needleſs to inſiſt here on their conſtruction. They have been deſcribed in the article ELECTRICITY (*Ency. l.*); and any perſon well acquainted with its theory, as laid down in the *Supplementary* article ELECTRICITY, will be at no loſs to accommodate his own conſtruction to his ſituation and purpoſes.

Dr Franklin took the lead, as we have already obſerved, in this examination of the electrical ſtate of the atmoſphere. He ſeldom found it without giving ſigns of electricity, and this was generally negative. See *Phil. Tranſ.* Vol. XLVIII. p. 358. and 785.

Mr Canton repeated thoſe experiments, and found the ſame reſults; both, however, found that the electricity would frequently change from poſitive to negative, and from negative to poſitive, in very ſhort ſpaces of time, as different portions of clouds or air paſſed the thunder-rod.

5 Cautions to be obſerved in the examination by a thunder rod.

We muſt here remark, that our acquaintance with the laws of electricity ſufficiently informs us, that the electricity of our thunder rod may frequently be of a different kind from that of the cloud which excites the appearances at our apparatus. We know that air, like glaſs, is a non-conductor; and that when it is brought into any ſtate of electricity, either by communication, or by mere induction, it will remain in that ſtate for ſome time, and that it always changes its electricity *per ſtratum*. A poſitive cloud, in the higher regions of the atmoſphere, will render the air immediately below it negative, and a ſtratum below that poſitive. If the thunder rod be in this poſitive ſtratum, it will exhibit poſitive electricity; but if the cloud be conſiderably nearer, the rod, by being in the adjoining negative ſtratum, may ſhow a negative electricity, which will exceed the poſitive electricity which the diſtant poſitive cloud would have induced on its lower end by mere poſition, had the intervening air been away. This exceſs of negative electricity muſt depend on the degree in which the ſurrounding ſtratum of air has been rendered negative. If this has been the almoſt inſtantaneous effect of the preſence of the poſitive cloud, it cannot be rendered ſo negative as to produce negative electricity in the lower

end

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water, by the iron and coaly matters, which are expoſed to the joint action of fire and water. Theſe two electricities will be oppoſite; or when not oppoſite, will not be equal: in either of which caſes, we have vaſt maſſes of ſteam in ſtates fit for flaſhing into each other.

A fact more to our purpoſe is, that if a ſilk or linen cloth, of a downy texture, be moiſtened or damped, and hung before a clear fire to dry, the fibres briſtle up, and on bringing the finger, or a metal knob, near them, they are plainly attracted by it. We found them negatively electric. This ſhews that the ſimple ſolution of water in air produces electricity. And this is the chief operation in Nature connected with the ſtate of the atmoſphere. It is thus that the watery vapours from all bodies, and particularly the copious exſudation of plants, diſappear in our atmoſphere. There can be no doubt but that the oppoſite electricity will be produced by the precipitation of this vapour; that is, by the formation of clouds in clear air. When damp, but clear air in one veſſel expands into an adjoining veſſel, from which the air has been exhauſted, a cloud appears in both, and a delicate electrometer is affected in both veſſels; but our apparatus was not fitted for aſcertaining the kind of electricity produced. Here then is another unexplored field of experiment. We got two veſſels made, having diaphragms of thin ſilk. Theſe were damped, and ſet into two tubs of water, of very different temperatures. Dry air was then blown thro' them, and came from their ſpouts ſaturated with water. The ſpouts were turned toward each other. Being of very different temperatures, the ſtreams produced a cloud upon mixing together, and a ſtrong negative electricity was produced. We even found that an electrometer, placed in a veſſel filled with condenſed air, was affected when this air was allowed to ruſh out by a large hole.

Laſtly, we know that the tourmaline, and many of the columnar cryſtals, are rendered electrical by merely heating and cooling. Nay, Mr Canton found that dry air became negative by heating, and poſitive by cooling, even when it was not permitted to expand or contract.

When water is precipitated, and forms a cloud, it is reaſonable to expect that it will have the electricity of the air from which it is precipitated. This may be various, but in general negative: For the heat by which the air was enabled to diſſolve the water made it negative; and much more the friction on the ſurface of the earth. But as heat cauſed it to diſſolve the water, cold will make it precipitate it; and we ſhould therefore expect that the air will be in the ſtate in which it was when it took up the water. But if it be cooled ſo faſt as to precipitate it in the form of rain, or ſnow, or hail we may expect poſitive electricity. Accordingly, in ſummer, hail ſhowers always ſhew ſtrong poſitive electricity; ſo does ſnow when falling dry.

Here, then, are copious ſources of atmoſpheric electricity. The mere expanſion and condenſation of the air, and ſtill more the ſolution and precipitation of watery vapours in it, are perhaps ſufficient to account for all the inequality of electric ſtate that we obſerve in the atmoſphere.

The maſſes of air thus differently conſtituted are evidently diſpoſed in ſtrata The clouds are ſeen to be ſo. Theſe clouds are not the ſtrata, but the boundaries of ſtrata; which, from the very nature of things, are in different ſtates with reſpect to the ſuſception or precipitation of water. When two ſuch ſtrata are thus adjoining, they will ſlowly act on each other's temperature, and by mixing will form a thin ſtratum of cloud along their mutual confines. If the one ſtratum has any motion relative to the other, and be in the ſmalleſt degree diſturbed, they will mix to a greater depth in each; and this mixture will not be perfectly uniform. The extreme mobility of air will greatly increaſe this jumble of the adjoining parts of the two ſtrata, and will give the cloud a greater thickneſs. If the jumble has been very great, ſo as to puſh one of them through the other, we ſhall have great towering clouds, perhaps pervading the whole thickneſs of the ſtratum of air. We take theſe clouds to be like great foggy bladders, ſuperficially opaque where they have come into contact with the ſurrounding ſtratum of air, but tranſparent within.

9 Strata of the atmoſphere are of different ſtates of electricity, and are tranſparent.

When the wind, or ſtratum in motion, does not puſh all the quieſcent air before it, it generally gets over it, and then flows along its upper ſide, and, by a partial mixing, produces a fleecy cloud, as already deſcribed. We may obſerve here, by the way, that the motion of thoſe fleecy clouds is by no means a juſt indication of the motion of the ſtratum; it is nearly the motion compoſed of the half of the motions of the two.

10 Theſe ſtrata have ſtrata of clouds interpoſed.

This is in all probability the ſtate of the atmoſphere, conſiſting of ſtrata of clear air many hundred yards thick, ſeparated from each other by thin fleeces of clouds, which have been produced by the mixture of the two adjoining ſtrata. This is no fancy; for we actually ſee the ſky ſeparated by ſtrata of clouds at a great diſtance from each other. And we ſee that theſe ſtrata maintain their ſituations, without farther admixture, for a long time, the bounding clouds continuing all the while to move in different directions. In the year 1759, during the ſiege of Quebec, a hard gale blew one day from the weſtward, which made it almoſt impracticable to ſend a number of proviſion boats to our troops ſtationed above the town. While the men were tugging hard at the oars againſt the wind, and hardly advancing, though the tide of flood favoured them, the French threw ſome bombs to deſtroy the boats. One of theſe burſt in the air, near the top of its flight, which was about a quarter of a mile high. The round ball of ſmoke produced by the exploſion remained in the ſame ſpot for above ſeven minutes, and diſappeared by gradual diffuſion. The lower air was moving to the eaſtward at leaſt 30 feet per ſecond.

In 1783, when a great fleet rendezvouſed in Leith Roads, the ſhips were detained by an eaſterly wind, which had blown for ſix weeks without intermiſſion. The ſky was generally clear; ſometimes there was a thin fleece of clouds at a great height, moving much more ſlowly in the ſame direction with the wind below. During the laſt eight days, the upper current was from the weſtward, as appeared by the motion of the upper clouds. High towering clouds came down the river, with a little rain; the ſtrata were jumbled, and the whole atmoſphere grew hazy and uniform; then came thunder, and heavy rain, and the wind below ſhifted to the weſtward.

Thus it is ſufficiently evinced, that the atmoſphere frequently conſiſts of ſuch ſtrata, well diſtinguiſhed from each

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each other: their appearance and progreſs leave us no room to doubt but that they come from different quarters, and had been taken up or formed at different places, and in different circumſtances, and therefore differing in reſpect of their electrical ſtates.

11 The electric equilibrium is reſtored very ſlowly in general.

The conſequence of their continuing long together would be a gradual but ſlow progreſs of their electricity to a ſtate of equilibrium. The air is perhaps never in a perfectly dry ſtate, and its moiſture will cauſe the electricity to diffuſe itſelf gradually. It is not beyond the power of our mathematics to aſcertain the progreſs of this approximation to the electric equilibrium. We ſee ſomething very like it in the curious experiments of Beccaria with mirror plates laid together, and charged by means of a coating on the outer plates. Theſe plates were found to conſiſt of alternate ſtrata of poſitive and negative electricity, which gradually penetrated through the plates, and coaleſced till they were reduced to two ſtrata; perhaps in time the electricity would have diſappeared entirely by theſe two alſo coaleſcing. In the ſame manner there would be a ſlow transfuſion of ſenſible electricity through theſe ſtrata without any ſenſible appearances. If any collateral cauſes ſhould make a part more damp than the reſt, there would be a more briſk transference through it, accompanied with faint flaſhes of lambent lightning.

12 A rapid and extenſive reſtoration is a thunder clap.

But thunder requires a rapid communication, and a reſtoration of electric equilibrium in an inſtant, and to a vaſt extent. The means for this are at hand, furniſhed by Nature. The ſtrata of charged air are furniſhed with a coating of cloud. The lower ſtratum is coated on the underſide by the earth.

13 Manner in which this is effected by a coating of cloud.

When a jumble is made in any of the ſtrata, a precipitation of vapour muſt generally follow. Thus a conductor is brought between the electrical coatings. This will quickly enlarge, as we ſee that in our little imitations the knobs of our conductors inſtantaneouſly arrange any particles of duſt which chance to lie in the way, in ſuch a manner as to complete the line of conduct, and occaſion a ſpark to fly to a much greater diſtance than it would have leaped if no duſt had been interpoſed. We have often procured a diſcharge between two knobs which were too far aſunder, by merely breathing the damp air between them. In this manner the interpoſed cloud immediately attracts other clouds, grows ragged by the paſſage of electricity through clear air, where it cauſes a precipitation by altering the natural equilibrium of its electricity; for a certain quantity of electricity may be neceſſary for air's holding a certain quantity of vapour. Accordingly we ſee in a thunder ſtorm that ſmall clouds continually and ſuddenly form in parts formerly clear. Whatever cauſes thunder, does in fact promote this precipitation.

Theſe clouds have the electricity of the ſurrounding air, and muſt communicate it to others in an oppoſite ſtate, and within reach. They muſt approach them, and muſt afterwards recede from them, or from any that are in the ſame ſtate of electricity with themſelves. Hence their ragged forms, and the ſimilar form of the under ſurface of the great cloud; hence their continual and capricious ſhifting from place to place: they are carriers, which give and take between the other clouds, and they may become ſtepping ſtones for the general diſcharge.

If a ſmall cloud form a communication with the ground, and the great cloud be poſitive or negative, we muſt have a complete diſcharge, and all the electrical phenomena, with great violence; for this coating of vapour is abundantly complete for the purpoſe. It conſiſts of ſmall veſicles, which are ſufficiently near each other for diſcharging the whole air that is in their interſtices A phial coated with amalgam is by no means fully coated. If we hold it between the eye and the light, we ſhall ſee that it is only covered with a number of detached points of amalgam, which looks like a cobweb. Yet this glaſs is almoſt completely diſcharged by a ſingle ſpark, the reſiduum being hardly perceptible.

14 The discharge is commonly between the clouds.

The general ſcene of thunder is the heavens; and it is by no means a frequent caſe that a diſcharge is made into the earth. The air intervening between the earth and the loweſt coating is commonly very much confuſed in conſequence of the hills and dales, which, by altering the currents of the winds, toſs up the interior parts, and mix them with thoſe above. This generally keeps the earth pretty much in the ſame electrical ſtate as the loweſt ſtratum of clouds.

15 Which are horizontally diſtant.

Nor are the great thunder ſtorms in general inſtances of the reſtoration of equilibrium between two ſtrata immediately incumbent on each other. They ſeem, for the moſt part, to be ſtrokes between two parcels of air which are horizontally diſtant. This, however, we do not affirm with great confidence. Our chief reaſon for thinking ſo is, that in theſe great ſtorms the ſpark or ſhaft of forked lightning is directed horizontally, and ſometimes is ſeen at once through an extent of ſeveral miles.

16 Particular account of forked lightning, and explanation of the long continued and rumbling noiſe of thunder.

The nature of this ſpark has not, we think, been properly conſidered. It is ſimply compared to a long electrical ſpark, which we conceive to be drawn thro' pure air, and is conſidered as marking the actual transference of electricity from one end to the other. But this we doubt very much. We are certain of having obſerved ſhafts of lightning at one and the ſame inſtant ſtretching horizontally, though with many capricious zigzags and lateral ſputterings, at leaſt five miles. We cannot conceive this to have been the ſtriking diſtance, becauſe the greateſt vertical diſtance of the ſtrata is not the half of this. We rather think that it is a ſimultaneous range of diſcharges, each accompanied with light, differently bright, according to the electrical capacity of the cloud into which it is made; and if there is a real tranſference of electric matter on this occaſion (which we do not affirm), it is only of a ſmall quantity from one cloud to the next adjoining. This we think confirmed by the ſound of thunder. It is not a ſnap, incomparably louder than our loudeſt ſnap from coated glaſs; but a long continued, rumbling, and *very unequable* noiſe. There is no doubt but that this ſnap was almoſt ſimultaneous through the whole extent of the ſpark; but its different parts are conveyed to our ear in time, and are therefore heard by us in ſucceſſion; and it is not an uniform roar, but a rumbling noiſe, unequally loud, according as the different parts of the ſnap are indeed differently loud. We ſhould hear a noiſe of the ſame kind if we ſtood at one end of a long line of ſoldiers, who diſcharged their muſquets (differently loaded) in the ſame inſtant. When any part of the ſpark is very near us, and is not very diffuſe, the ſnap begins with great ſmartneſs, and continues for ſome time, not unlike the violent tearing of a piece of ſtrong ſilk; after which it becomes more and more mellow

Thunder. low as it comes from a greater distance. We do not, however, affirm, that the whole extensive spark and snap are co-existent or simultaneous. The cloud is, in all probability, but an indifferent conductor, and even a sensible time may elapse during the propagation of the spark to a great distance. Beccaria observed this in a line of 250 feet of chain, lying loosely on the ground, and consisting of near 6000 links. He thought that it employed a full second; but when the chain was gently stretched, the communication seemed instantaneous.

17 Observations of the electric spark.

We cannot help thinking that even the electrical snap between two metal knobs is of the same kind. Not a quantity of luminous matter which issues from the one and goes to the other, but a light that is excited or produced in different material interjacent particles of air or other interposed matter. The angular and sputtering quite incompatible with the motion of a simple luminous point. Nay, our chemical knowledge here comes in aid, and obliges us to speculate about the manner in which this light is produced. Whence does it come? It may be produced by two knobs of ice. We know that water consists of vital and inflammable air, which have already emitted the light which made an ingredient of their composition. The spark therefore does not come from the ice. Is it then from the air? If so, perhaps water is produced, or rather something else, for there is not always inflammable air at hand to compose water. Yet the transference of electricity has decomposed the air, or has robbed it of part of its light. The remainder may not be water; but it is no longer air. Is not this confirmed by the peculiar smell which always accompanies electric sparks? and the peculiar taste, not unlike the taste felt on the tongue when it is touched by the zinc in the experiments on Galvanism? Even the fine pencil of light which flows from a point positively electrified, appears through a magnifying glass to consist, not of luminous lines, but of lines of luminous points. And these points are of different brilliancy and different colour, both of which are incessantly changing. And be it farther observed, that these lines are curves, diverging from each other, and convex to the axis. This circumstance indicates a mutual repulsion, arising, in all probability, from the expansion of the air. And, lastly, no spark nor light of any kind can be obtained in a space perfectly void of air.

All these circumstances concur in explaining the nature of the shaft of forked lightning. It is a series of appearances excited in the intervening medium, and which produce some chemical change in it. Thunder, when it strikes a house, always leaves a peculiar smell. Inflammable air has also a peculiar and very disagreeable smell. The smell produced by electricity greatly resembles the smell produced by striking two pieces of quartz together.

18 Deluc's notion of thunder not probable.

Mr Deluc supposes that the electrical spark, as it is exhibited in thunder, is always accompanied by the decomposition of air now so familiarly known, and that this is the origin of the deluge of rain which commonly finishes the storm. But this is not in the smallest degree probable. The decomposition extends surely no farther than where the light is separated; and we should no more expect a deluge of rain, even if we had inflammable air ready at hand, than we expect drops of water in our electrical experiments. Something different from water follows this decomposition, total or partial, of the vital air; and the water which we do observe to accompany thunder, is no more than what we should expect from the copious precipitation of water in a cloudy form. Mr Saussure's observations assure us, that the particles of a cloud are vesicles. Indeed no person who has looked narrowly at a fog, or has observed how large the particles are of the cloud which forms in a receiver when we suddenly diminish the density of the air, and who observes how slowly these particles descend, can doubt of their being hollow vesicles. We cannot perhaps explain their formation; but there they are. We can hardly conceive them receiving the commotion which accompanied the snap without collapsing by the agitation. Perhaps the very cessation of their electricity may produce this effect. They will therefore no longer float in the air, but fall, and unite, and come to the ground in rain. We may expect this rain to be copious, for it is the produce of two strata of clouds. It greatly contributes to the putting an end to the storm, by passing through the strata, and helping to restore the equilibrium.

19 Why and how thunder may continue for some time.

One may at first expect that a single clap of thunder will restore the equilibrium of any extent of clouds, and we require an explanation of their frequent repetition before this is accomplished. This is not difficult, and the fact is a confirmation of the above theory, which is considerably different from the generally received notions of the subject. We consider the stratum of clear air as the charged electric; positive on one side, and negative on the other, and coated with conducting clouds. When the discharge is made, the state of electricity is indeed changed through the whole stratum, but the equilibrium is by no means completed. The stratum is perhaps a quarter of a mile in thickness. The discharge does not immediately affect all this; but does it superficially, leaving the rest unbalanced. It is like the residuum which is left in a Leyden phial when the discharge has been made by means of a spark drawn at a distance. It is still more like the residuum of the discharge of a Leyden phial that is coated only in patches on one side. Each of these patches discharge what is immediately under it and round it to a certain small distance, but leaves a part beyond this still charged. This redundant electricity gradually diffuses itself into the spaces just now discharged; and, after some considerable time has elapsed, another discharge may be made. In like manner, the electricity remaining in the interior of the stratum diffuses itself, comes within the action of the coating, and may be again discharged by a clap of thunder. We have a still better parallel to this in Beccaria's experiments with two or more plates of glass laid together. After the first discharge, the internal surfaces will exhibit certain electricity. Lay the plates together, and, after some time, the electricity of the inner surfaces will be different, and another discharge may be obtained.

Magnetism affords the best illustration of this. If a magnet be brought near a piece of soft iron, lying below a paper on which iron filings are lightly strewed, it will instantly induce a north pole on one end and a south pole on the other; and this will be distinctly observed by the way in which these filings will arrange themselves. But if, instead of soft iron, we place a bar of hard tempered steel, the south pole will be but a small

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small matter removed from the north pole; but by continuing the magnet long in the same place, the distribution of magnetism in the piece of hard steel will gradually advance along the bar, and after a long time the neutral point will be almost in the middle of the bar, and the south pole will be at the farther end. See MAGNETISM in this *Suppl*

20
Most thunder strokes are RETURNING STROKES

We said that the clouds were the usual scenes of the violent electric phenomena. We imagine that the greatest part of the thunder strokes which have been felt have been of the kind which Lord Mahon, now Lord Stanhope, calls the returning stroke. If two clouds A and B are incumbent over the plain *a* and *b*; and if A be positive and B negative the earth will be maintained in a negative state at *a*, and a positive state at *b*. If the discharge be now made between the clouds A and B, the electricity must instantly rush up through a conductor at *a*, and down through one at *b*, and each place will have a stroke. The same thing will happen if the negative cloud B is above the positive cloud A, but not in so great a degree; for the negative electricity at *a* will now be much less than in the other case, because it is induced only by the prevalence of the positive cloud A over the more remote negative cloud B.

— B

+ b

This returning stroke explains, much better than we can by any direct stroke, the capricious effects of thunder A person at Vienna received a terrible shock by having his hand on a thunder-rod during a violent explosion which he saw above three miles distant. Sparks are observed at thunder rods at every the most distant flash of lightning.

21
Beccaria's theory of thunder not just.

Beccaria has a different theory of thunder. He imagines that the different parts of the earth are in different states of electricity, and that the clouds are the restoring conductors. But this does not accord with what we know of electricity. The earth is so good a conductor, that Dr Watson could not observe any time lost in communicating the electricity to the distance of more than four miles. It is very true, that the earth is almost always in a state of very unequal, and even opposite, electricity in its different parts; but this arises from the variety of clouds strongly electrified in the opposite way This induces electricity, or disturbs the natural uniform diffusion of electricity, just as the bringing magnets or loadstones into the neighbourhood of a piece of iron, without touching it, renders it magnetical in its different parts. While they continue in their places, the piece of iron will be magnetical, and differently so in its different parts.

Such are the thoughts which occur to us on this subject. But we by no means affirm that we have given a full account of the procedure of Nature; we have only pointed out several necessary consequences of the known laws of electricity, and of its production in the atmosphere by means of natural operations which are continually going on. These *must* operate, and produce an electrical state of the atmosphere greatly resembling what we observe: and we have shewn, from the acknowledged doctrines of electricity, how this want of equilibrium may be removed, and must be removed, by the same operations of Nature. The equilibrium must be restored by means of the conducting coating furnished by the clouds. But these may be the least considerable of Nature's resources; and the subject is still an unexplored field, in the examination of which we may hope to make great progress, in consequence of our daily increasing knowledge of the chemical state of the atmosphere.

22
Dr Franklin's invention of a guard against thunder.

Knowledge is valuable chiefly as it is useful. No man ever saw the propriety of this apothegm more strongly than Dr Franklin, or more assiduously adhered to it in the course of a long and studious life. However greatly we may admire his sagacity, penetration, and logical discrimination, in the discoveries he has made in the science of electricity, and his discovery of the identity of electricity and thunder, we must acknowledge infinitely greater obligations to him for putting it in our power to ward off the fatal, and formerly inevitable stroke, of this awful agent in the hands of Nature.

Dr Franklin considers the earth as performing the office of conductor in restoring the electric equilibrium of the atmosphere, which has been disturbed by the incessant action of the unwearied powers of Nature.

He observes that the usual preference will be given to the best conductors. In this respect, a metal rod far surpasses the brick, stone, timber, and other materials which compose our buildings, especially when they are dry, as is usually the case in the thundery season. He therefore advises us to place metalline conductors in the way of the atmospherical electricity, in those places where it is most likely to strike, and to continue them down to the moist earth, at some depth under the surface. Nay, as it has been found that thunder has not in every instance struck the highest parts of buildings, he advises to raise the metalline conductors to some considerable height above the building, the more certainly to invite the electricity to take this course.

23
Directions for constructing it.

To ensure success, he observes that the electrical shock dissipates water, and even metalline conductors, when too small. He therefore advises to make the conductor at least half an inch square, none of that size having ever been destroyed, though smaller have, by the thunder; yet even these had conducted the thunder to the ground with perfect safety to the building.

No part of a conductor must terminate in the building; for the electricity accumulates exceedingly at the remote extremities of all long rods, and tends to fly off with great force, especially if another conductor is near. This aids the accumulation, by acquiring at its upper end an electricity opposite to that of the lower end of the other: and this effect, produced by the influence of a positive cloud, makes the upper and negative end of the lower portion of a divided conductor draw more electricity to the lower end of the upper portion. This redundant electricity, strongly attracted by the negative lower portion, flies off with great violence through the air; or if surrounded with any matter capable of conversion into elastic vapour by heat, bursts it with irresistible force. Thus the thunder, acting on the vane spindle of St Bride's steeple in London, sprung from its lower end to the upper end of an iron window bar, and burst the stone in which it was fixed, by expanding the moisture into steam. In like manner it burst the stone at the lower end of this bar, to make its way to an iron cramp which connected the opposite sides of the steeple; from this it struck to another cramp; and so from

cramp to cramp, till it reached the gutter leads of the church, burſting and throwing off the ſtonework in many places.

All interruptions muſt therefore be carefully avoided, and the whole muſt be made as much as poſſible one continued metal rod.

Farther, Dr Franklin, obſerving the ſingular property which ſharp points poſſeſs of drawing off the electricity in ſilence, adviſes us to finiſh our conductor with a fine point of gilt copper, which cannot be blunted by ruſt.

24
Is the common conductor an effectual and ſafe contrivance?

But as thus raiſing the conductor, and pointing it, are ſo many invitations to the thunder to take this courſe; and as we cannot be certain that the quantity thus invited may not be more than what the rod can conduct with ſafety—it has appeared to Dr Wilſon, and other able electricians, that it will be ſafer to give abundance of conduct to what may unavoidably viſit us, without inviting what might otherwiſe have gone harmleſsly by.

This was attentively conſidered by Dr Franklin, Dr Watſon, Mr Canton, Dr Wilſon, and others, met as a committee of the Royal Society, at the deſire of the Board of Ordnance, to contrive a conductor for the powder magazine at Purfleet.

We think that the theory of induced electricity, founded on Dr Franklin's diſcoveries, and confirmed by all the later inventions of the electrophorus, condenſer, &c. will decide this queſtion in the moſt ſatisfactory manner.

25
Scientific account of the ſtate of electricity induced on a building by a thunder cloud,

When a cloud poſitively electrified comes over a building, it renders it negatively electrical in all its parts, if of conducting materials, and even the ground on which it ſtands. This effect is more remarkably produced if the ſtructure is of a tall and ſlender ſhape, like a ſteeple or a rod. Therefore the external electrical fluid is attracted by the building with greater force than if it had conſiſted of materials leſs conductive. A diſcharge will therefore be made through it in preference to any neighbouring building, becauſe it is more eminently negative. For the ſame reaſon, if there are two buildings equal and ſimilar, one of them being a good conductor, and the other being a leſs perfect one, the perfect conductor, becoming more powerfully negative, the cloud will become more ſtrongly poſitive over this houſe than over the other, and the ſtroke will be made through it.

26
And on the thunder rod.

The ſame thing muſt obtain in a perfect conductor continued from the top to the foundation of a houſe, built of worſe conducting materials. The conductor becoming more eminently negative than any other part of the building, the electric fluid will be more ſtrongly attracted by it, accumulated in its neighbourhood, and will all be diſcharged through it, ſo long as it is able to conduct.

If the building is of great extent, the proximity of one part of the building to the thunder cloud may produce an accumulation of electrical fluid in its neighbourhood, in preference to a more perfect, but remote, conductor. But when the diſtances from the cloud are not very unequal, the accumulation will always be in the neighbourhood of the perfect conductor; and this will determine the diſcharge that way. The accumulation in the neighbourhood of the rod will be ſmall indeed, when the rod is ſmall; but then it is denſe, and the whole of electric phenomena ſhew that it is the denſity, and not the quantity, of accumulation which produces the violent tendency to fly off: it is this alone which makes it impoſſible to confine electricity in a body which terminates in a ſharp point.

For the ſame reaſon, bodies of the ſame materials and ſhape will increaſe the accumulation in the adjoining part of the cloud in proportion as they are nearer to it, or more advanced beyond the reſt of the building.

And bodies of ſlender ſhape, and pointed, will produce this accumulation in their neighbourhood in a ſtill more remarkable degree, and determine the courſe of the diſcharge with ſtill greater certainty.

But it is evident that a metallic rod, no higher than the reſt of the building, may occaſion an accumulation in the adjoining part of a near thunder cloud ſufficient to produce a diſcharge, when the building itſelf, conſiſting of imperfect conductors, would not have provoked the diſcharge at all. It may therefore be doubted whether we have derived any advantage from the conductor.

27
Effect of all interruptions in the conductor.

To judge properly of this, we muſt conſider houſes as they really are, conſiſting of different materials, in very different ſhapes and ſituations; and particularly as having many large pieces of metal in their conſtruction, in various poſitions with regard to the cloud, the ground, and to each other. Suppoſe all the reſt of the building to be of non-conducting materials. When a poſitive thunder cloud comes overhead, every piece of metal in the building becomes electrical, without having received any thing as yet from the cloud; that end of each which is neareſt the cloud becoming negative, and the remote end poſitive. But, moreover, the electricity of one increaſes the electricity of its neighbour. Then the moſt elevated becomes more ſtrongly attractive at its upper end than it would have been had the others been away; and therefore produces a greater accumulation in the nearer part of the thunder cloud than it would otherwiſe have done, and it will receive a ſpark. By this its lower end becomes more overcharged, and this makes the upper end of the next more undercharged, and the ſpark is communicated to it, and ſo on to the ground; which would not have happened without this ſucceſſion of conductors. Thus it is eaſy to conceive, that the accumulation in the cloud is juſt inſufficient to produce a diſcharge—While things are in this ſtate, juſt ready to ſnap, ſhould a man chance to paſs under a bell wire, or under a luſtre hanging by a chain, his body will immediately augment the poſitive electricity of the lower end of the conductor above him, and thus will augment the negative electricity of its upper end. This again will produce the ſame effect in the conductor above it: and thus each conductor becomes more overcharged at its lower end, and more undercharged at the upper end. Before this, every thing was juſt ready to ſnap. All will now ſtrike at once. The cloud will be diſcharged through the houſe, and the man will be the ſacrifice, the whole diſcharge being made through his body. This needs no demonſtration for any well-informed electrician. Thoſe who have only ſuch a knowledge of the theory as can be gathered from the writings of Prieſtley, Cavallo, and other popular authors, may convince themſelves of the truth of what is here delivered in the following manner.

In dry weather, and the moſt favourable circumſtances for good electrical experiments, let a very large globe,

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globe, smoothly covered with metal, and well insulated, be as highly electrified as possible, without exposing it to a rapid dissipation. To ensure this circumstance (which is important) let it be electrified till it begins to sputter, and note the state of the electrometer. Discharge this electricity, and electrify it to about half of this intensity. Provide three or four insulated metal conductors, about three inches long and an inch diameter, terminated by hemispheres, and all well polished.

Having electrified the globe, as above directed, bring one of the insulated conductors slowly up to it, and note its distance when it receives a spark. In doing this, take care that there be no conducting body near the remote end of the insulated conductor. It will be best to push it gradually forward by means of a long glass rod. Withdraw the conductor, discharge its electricity, restore the globe to its former electricity, indicated by an electrometer, and repeat this experiment till the greatest striking distance is exactly discovered. Now set another of the insulated conductors about half an inch behind the first, and push them forward together, by a glass rod, till a spark is obtained. The striking distance will be found greater than before. Then repeat this last experiment, with this difference, that the two conductors are pushed forward by taking hold of the remote one. The striking distance will be found much greater than before. Lastly, push forward the two conductors, the remote one having a wire communicating with the ground, till they are a small matter *without* the striking distance; and, leaving them in this situation, take any little conducting body, such as a brass ball fixed on the end of a glass rod, and pass it briskly through between the globe and the nearest conductor, or through between the two conductors, taking care that it touch neither of them in the passage. It will be seen that, however swift the passage is made, there will be a discharge through all the four bodies. The inference from this is obvious and demonstrative.

A very remarkable instance of this fact was seen at the chapel in Tottenham Court Road, London. A man, going into the chapel by the east door, was killed by the thunder, which came down from the little bell-house, along the bell-wire, and the rod of the clock pendulum, from the end of which it leaped to some iron work above the door, and from thence, from nail to nail, till it reached the man's head.

This interruption of conduct, which is almost unavoidable in the construction of any building, is the cause of most of the accidents that are recorded; for when the ends of those communicating conductors are inclosed in materials of less conducting power, the electricity, in making its way to the next in a very dense state, never fails to explode every thing which can be converted into elastic vapour by heat. There is always a sufficient quantity of moisture in the stone or brickwork for this purpose; and most vegetable substances contain moisture or other expansible matter. The stone, brick, or timber, is burst, and thrown to a considerable distance; or if kept together by a weight of wall, the wall is shattered. It is worth remarking that although no force whatever seems able to prevent this explosion, the quantity of matter exploded is extremely small; for the stones are never thrown to a greater distance than they would have been by two or three grains of gunpowder properly confined.

All these accidents will be prevented by giving a sufficient uninterrupted conduct; and it is proper to make use of such a conductor, although it may invite many discharges which would not otherwise happen. So long as the conductor is sufficient for the purpose, there seems to be no doubt of the propriety of this maxim.

25 A thunder rod will protect even when it is not able to discharge the whole thunder.

But the most serious objection remains. As we are certain that these conductors, whether raised above the building or not, will produce discharges through them which otherwise would not have happened, and as we are quite uncertain whether the quantity contained in a thunder cloud may not greatly exceed what the thunder rod can conduct without being dissipated in smoke, it seems very dangerous thus to invite a stroke which our conductor may not be able to discharge. In particular, it is reasonable to believe that the strata of electrified clouds which come near the earth lose much of their electricity by passing over the sharp points of trees, &c. while those which are much higher may retain their electricity undiminished, and pass on. May it not therefore happen, that our conductor will invite a fatal stroke, which would have gone harmlessly by?

The doubt is natural, and it is important.

Let us suppose a very extensive and highly electrified cloud, in a positive state, to come within such a distance from a building as *just not to strike it*, if unprovided with a conductor, but which will most certainly strike the same building furnished with a conductor; and let the electricity be so great that the conductor shall be dissipated in smoke before even a small part of it is discharged—What will be the fate of the building? We believe that it will be perfectly safe.

However rapid we may suppose that motion by which electricity is communicated, it is still motion, and time elapses during the propagation. The cloud is discharged, not in a very instant, but in a very short time. Part of the cloud is therefore discharged, while it explodes the conductor, and the electricity of the remainder is now too weak (by our supposition) to strike the building no longer furnished with a conductor. This must be the case, however large and powerful the cloud may be, and however small the conductor.

But suppose that the cloud has come so near as to strike the building unprovided with a conductor. Then as much will be discharged through the building as it can conduct; and if the quantity be too great, the building will be destroyed: but let a conductor (tho' insufficient) be added. The discharge will be made through it as long as it lasts, and the remainder only will be discharged through the house, surely with much less danger than before.

The truth of these conclusions from theory is fully verified by fact. When the church of Newbury in New England was struck by lightning in 1755, a bell wire, no bigger than a knitting needle, conducted the thunder with perfect safety to the building as far down the steeple as the wire reached, though the stroke was so great that the wire had been exploded, and no part of it remained, but only a mark along the wall occasioned by its smoke. From the termination of the wire to the ground the steeple was exceedingly shattered, and stones of great weight were thrown out from the foundation (where they were probably moister) to the distance of 20 and 30 feet.

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'Another remarkable instance happened in the summer palace at St Petersburg. A Heyduk and a soldier of a foot regiment were standing centinels at the door of the jewel-chamber: the Heyduk, with his scimitar resting on his arm, was carelessly leaning on the soldier, who had his musket shouldered. Both were struck down with lightning; and the soldier was killed, his left leg scorched, and his shoes burst. The Heyduk had received no damage, but felt himself tripped up, as if a great dog had run against him. A narrow slip of gold lace, which was sewed along the seam of his jacket and pantaloon breeches, reaching to his shoes, had been exploded on the left side. This seems to have been his protection. In all probability, the stroke came to both along the musket (or perhaps to the Heyduk along the scimitar). The Heyduk had a complete, though insufficient, conductor, and was safe. The soldier had not, and was killed. The push felt by the former probably arose from the explosion of the lace.

It seems therefore plain that metalline conductors are always a protection; that advancing them above the building, increases their protection; and that pointing them may sometimes enable them to diminish a stroke, by discharging part of the electricity silently.

Dr Franklin having formed all his notions of thunder from his pre-established theory, and having seen the principal phenomena so conformable to it, was naturally led to expect this conformity in cases which he could not easily examine precisely by experiment. Accordingly, in his first dissertation, he affirmed that a fine point always discharges a thunder cloud silently, and at a great distance. The analogous experiments in artificial electricity are so beautiful and so perspicuous, that this confidence in the protecting power of fine points is not surprising: and this confidence was rendered almost complete by a most singular case which fell under his own observation He was awakened one night by loud cracks in his stair case, as if some person had been lashing the wainscoating with a great horsewhip. He thought it so, and got up in anger to chide the idle fool. On looking out at his chamber door, he saw that the disturbance proceeded from electric explosions at some interruptions of his conductor. He saw the electricity pass, sometimes in bright sparks, producing those loud thwacks, and sometimes in a long continued stream of dense white dazzling light as big as his finger, illuminating the stair-case like sunshine, and making a loud noise like a cutler's wheel. Had the cloud (says he) retained all this till it came within striking distance, the consequences would have been inconceivably dreadful. Yet not long after this he found that he had been in a mistake; for the house of Mr Watt in Philadelphia, furnished with a finely pointed conductor, was struck by a terrible clap of thunder, and the point of the conductor was melted down about two inches. This is perhaps the only instance on record of a finely-pointed *conductor* being struck. The board room at the powder magazine at Purfleet was indeed struck, though provided with a conductor; but the stroke was through another part of the building. St Peter's church, Cornhill, has been eight times struck between 1772 and 1787; while St Michael's, in its neighbourhood, and much higher, has never had a stroke since 1772, when it was furnished with an excellent pointed conductor by Mr Nairne.

Dr Franklin having seen the above exception to his rule, and reflected on it, acknowledges that there are cases where a pointed conductor may be struck, viz. when it serves as a stepping stone, to *complete* a canal of conveyance already near completed. A *small* cloud may sometimes serve as a stepping stone (like the man coming under a lustre) for the electricity to come out of a great cloud, and discharge through the pointed conductor. Whenever it comes to the striking distance from the conductor, it will explode at once; whereas the great cloud itself must have come nearer, and had its force gradually diminished. It is remarkable that a point, employed in this way in artificial electricity, must be brought nearer to another body than a ball need be, before it can receive a stroke. The difference is about one third of the whole. Nairne found, that a ball one nine tenths inches in diameter, exploded at the distance of nine inches, and a point at six inches distance.

29 A pointed conductor may sometimes be struck.

We must also observe that a pointed conductor can have no advantage over a blunt one in the case of a returning stroke; which is perhaps the most common of any. This depends on another discharge, which is made perhaps at a great distance. This was most distinctly the case in the instance mentioned some time ago, of the person at Vienna who had a shock from a thunder rod by an explosion far distant. This thunder rod was a very fine one, furnished with five gilt points.

30 Dr Franklin over-rated the protection of pointed conductors.

Still, however, this property of sharp points was greatly over-rated by Dr Franklin, and those who took all their notions of electricity from the simple discoveries of his sagacious mind. Unfortunately Dr Franklin had not cultivated mathematical knowledge; and, ever eager after discovery, and ardent in all his pursuits, his wonderful penetration carried him through, and seldom allowed him to rest long on false conclusions. He was certainly one of the greatest *philosophers*; and a little erudition would perhaps have brought him side by side with Newton. It was reserved, however, for Lord C. Cavendish and for Æpinus, to subject the investigations of Franklin to number and measure. By studying what they have written on the subject, or even the view which we have given of their theory in the article ELECTRICITY (*Suppl.*), the reader will be fully convinced, that a point has little or no advantage over a ball, with respect to a thunder cloud which is brought to the thunder rod by a brisk wind; although, when it comes slowly up during an almost perfect calm, it may discharge all that can be discharged without a snap. The constipation in a point is indeed very great, but the quantity constipated is moderate; and therefore its action, at any considerable distance, is but trifling. All this is fully verified by Dr Wilson's judicious experiments in the Pantheon. He had a prodigious quantity of electrified surface suspended there, and made a pointed apparatus come to its striking distance with a motion which he could regulate and measure. And he found that with the very moderate velocity of twelve feet in a second, he never failed of procuring a very smart stroke. The experiments made in the usual way by the partisans of sharp points (for it became a matter of indecent party) were numberless, and decidedly in their favour. The great and just authority of Dr Franklin, who was one of the committee, procured them still more consideration, or at least hindered people from seeing the force of Dr Wilson's reasoning. It is somewhat surprising.

prising, that Dr Wilson, a lover of mathematical learning, and a good judge, as appears from his publication of the papers of Mr Robins, did not himself see the full force of his own experiments. He had not surely studied either Æpinus or Cavendish. He indeed frequently says, that the state of the electricity in a thunder cloud, and in coated glass, is exceedingly different; and that the first extends its sensible influence much farther than the last, when both have the same quantity of electricity. But he seems not to have formed to himself any adequate notion of the difference. Had he done this, he would have seen that he has disposed his great electrified surface very improperly. It should have been collected much nearer his pointed apparatus, that this might, if possible, have been within the sphere of attraction of every part of his artificial cloud. He would then have found results, some of which would have been much more favourable to his own general opinion, while others would have exhibited the peculiarities of the sharp point in a more showy manner than any thing we have seen.

31 Thunder cloud very unlike coated glass;

Reasoning from the true theory of coated glass, we shall learn that, when the glass is exceedingly thin, the accumulation of electricity, or the charge, will be exceedingly great; while the external appearance, or apparent energy, of the electricity may be hardly sensible, and will extend to a very small distance. Thus, a circular plate of coated glass, six inches in diameter and one twentieth thick, when electrified so as to make an electrometer diverge 50 degrees, contains about 60 times as much electricity as a brass plate, of the same diameter, electrified to the same degree; and these two will have the same influence on an electrometer placed at a distance from them, and will give a spark nearly at the same distance. The spark from the coated glass will be bright, and will give a shock; while that from the brass plate will be trifling. The cause of the equality of influence is, that the positive electricity of the one side of the coated glass is almost balanced by the negative electricity of the other side, and the unbalanced part is about $\frac{1}{10}$th of the whole. If we now take a brass plate of $46\frac{1}{2}$ inches in diameter, and electrify it to the same degree with the coated glass, we shall find that it will require the same number of turns of the machine to bring it to this state, or to charge the coated glass. They contain the same quantity of electricity, and the spark of both will give the same shock. But this large plate will have a much wider influence: a person coming within ten feet of it will see his hair bend towards it, and feel like a cobweb on his face.

32 And the influence of sharp points is trifling.

It may be farther demonstrated that the power of a point to abstract the electricity to a given degree from the large plate, is vastly smaller than its power to abstract it to the same degree from the coated plate. This is different in the different degrees of the abstraction, and cannot be expressed by any one number.

All these considerations taken together, shew us that the pointed conductor has little advantage over the ball in the circumstance above-mentioned. It has, however, an advantage, and therefore should be employed; and in the case of a calm, or very gentle progress of the thunder cloud, the advantage may be very great.

33 An extensive and substantial metalline conductor is the chief security.

Thus we think the question decided; and the only remaining consideration is the quantity of metallic conduct that should be given. Prudence teaches us not to spare, especially in very lofty buildings. The conductor on the dome of St Paul's in London consists of four iron straps, each four inches broad and one half an inch thick. This conductor was once made red hot by a thunder stroke. No instance has been found of a rod one half an inch square being exploded. The accident at Mr Watt's house in Philadelphia is curious. The brass wire which terminated the rod had been ten inches long and one-fourth thick at the base, and two one-half inches were melted. It was unable, therefore, to conduct that stroke when its diameter was less than one-sixteenth of an inch.

We recommend lead or copper in preference to iron. Iron wastes by rust, and by exfoliating retains water, which may be dangerous by its expansion. A strap of lead, two inches broad and one fourth thick, stapled down to the roof or wall with brass staples, secures us from all risks from neglect. An iron rod, or one fastened with iron cramps, requires frequent inspection, to see that nothing has failed or wasted by rust. The point or points should surely be copper. It would be very proper to connect all the leads of the ridges, gutters, and spouts, with the conductor, by straps of lead. This will greatly extend its protection.

A great extent of building is not sufficiently secured by one conductor. And a powder magazine should have some erected round it at a distance on masts.

Maxims in a Thunder Storm.

Avoid being under trees—but be near them: do not avoid rain. When in a room, avoid the fire-side, which would bring you into the neighbourhood of the highest part of the house, viz. the stack of chimneys. The bell-wire, the grate, the fire irons are bad neighbours. Nay, the foot of the chimney is not a good one, especially if it has ever caked together by burning (A). Go to the middle of the room, and sit down, if not near a lustre, or any thing hanging from the ceiling. Avoid mirrors, or gilded mouldings.

Thunder Clouds, in physiology, are those clouds which are in a state fit for producing lightning and thunder. See the preceding article.

(A) In the terrible thunder stroke on Leven House in Scotland, the two great streams of electricity had taken the course of the vents which had been most in use, but not to get at the iron work, for it had branched off from the vents, at a great distance from the bottom. The chief conductors through the building had been various gilded mouldings, gilded leather hangings, gilded skreens, picture frames, and the foil of mirrors. In this progress the steps have been so many, and so capricious, that no line of progress can be traced, according to any principle. The thunder seems to have electrified at once the whole of the leaden roof, and, besides the two main tracks along the vents, to have afterwards darted at every metal thing in its way. The lowest point of the track was a leaden water cistern; which, however, received no damage; but a thick stone wall was burst through to get at it.

THUS, in sea-language, a word used by the pilot in directing the helmsman or steersman to keep the ship in her present situation when sailing with a scant wind, so that she may not approach too near the direction of the wind, which would shiver her sails, nor fall to leeward, and run farther out of her course.

TIBERIAS (anc. geog.), the last town of Galilee, situated on the south side of the lake Tiberias; built by Herod the Tetrarch, and called *Tiberias* in honour of the Emperor Tiberius; distant 30 stadia from Hippus, 60 from Gadara, and 120 from Scythopolis: whence it appears to have been at no great distance from where the Jordan runs out of the lake. It is a number of times mentioned by St John the Evangelist. Pliny places it on the west extremity of the lake, commending the salubrity of its hot waters. Jerome says, the ancient name was *Chenereth*; which, if true, will account for the name of the lake.

TIERRA DEL FUEGO, several islands at the southern extremity of America. They take their name from a volcano on the largest of them. They are all very barren and mountainous; but from what Mr Forster says, in his Voyage to the South Sea, the climate does not appear to be so rigorous and tempestuous as it is represented in Anson's Voyage. Upon the lower grounds and islands, that were sheltered by the high mountains, Mr Forster found several sorts of trees and plants, and a variety of birds. Among the trees was Winter's bark-tree, and a species of *arbutus*, loaded with red fruit of the size of small cherries, which were very well tasted. In some places there is also plenty of celery. Among the birds was a species of duck, of the size of a goose, which ran along the sea with amazing velocity, beating the water with its wings and feet. It had a grey plumage, with a yellow bill and feet, and a few white quill-feathers. At the Falkland islands it is called a *loggerhead-duck*. Among the birds are also plenty of geese and falcons. The rocks of some of the islands are covered with large muscle-shells, the fish of which is well flavoured. The natives of this country are short in their persons, not exceeding five feet six inches at most, their heads large, their faces broad, their cheek bones prominent, and their noses flat. They have little brown eyes, without life; their hair is black and lank, hanging about their heads in disorder, and besmeared with train-oil. On the chin they have a few straggling short hairs instead of a beard. The whole assemblage of their features forms the most loathsome picture of misery to which human nature can possibly be reduced. Those which Mr Forster saw had no other clothing than a small piece of seal skin, which hung from their shoulders to the middle of their back, being fastened round the neck with a string: the rest of their body was perfectly naked. Their natural colour seems to be an olive brown, with a kind of gloss, resembling that of copper; but many of them disguise themselves with streaks of red paint, and sometimes, though seldom, with white. Their whole character is a strange compound of stupidity, indifference, and inactivity. They have no other arms than bows and arrows; and their instruments for fishing are a kind of fish-gigs. They live chiefly on seals flesh, and like the fat oily part most. There is no appearance of any subordination among them; and their mode of life approaches nearer to that of brutes than that of any other nation.

TILLANDSIA, the large barren WILD PINE of the West Indies; a genus of the monogynia order, belonging to the hexandria class of plants. It is called *Caragatua* by Father Plumier, and is a parasitic plant, and ought perhaps, in strict propriety, to be denominated an *aquatic*: for although it is suspended in the air among the branches of lofty trees, to whose boughs it is fastened by its numerous roots; yet it is not indebted to those boughs, like the misletoe and other parasitic plants, for nourishment, but merely for support; provident Nature having, in a very extraordinary manner, supplied this with other means to preserve its existence: For the leaves, which much resemble those of the pine-apple, but are larger, surround this plant in a circular manner; each leaf being terminated near the stalk with a hollow bucket, which contains about half a pint of water. It is by these numerous small reservoirs of water that the roots, as well as every other part of this plant, are supplied with nourishment without the help of any earth. The flourishing condition of this plant, as well as the great growth of fig-trees, upon barren rocks, shews that water is of greater use to vegetation than earth.

One contrivance of Nature in this vegetable, says Dr Sloane, is truly admirable. The seed is crowned with many long downy threads, not only that it may be carried everywhere by the wind, but that by those threads, when driven through the boughs, it may be held fast, and stick to the arms and prominent parts of the barks of trees. So soon as it sprouts or germinates, although it be on the under part of a bough, its leaves and stalks rise perpendicular or erect: if they assumed any other direction, the cistern or reservoir just mentioned, made of the hollow leaves, could not hold water, which is necessary to the life and nourishment of the plant. In scarcity of water this reservoir is useful, not to the plant only, but to men, and even to birds and all sorts of insects, which come thither in troops, and seldom go away without refreshment.

To the same purpose, Dampier, in his Voyage to Campeachy, relates, "that the wild pine has leaves that will hold a pint and a half or quart of rain-water, which refreshes the leaves, and nourishes the roots. When we find these pines, we stick our knives into the leaves, just above the root; and the water gushing out, we catch it in our hats, as I myself have frequently done, to my great relief."

TIMÆUS, a Greek historian, the son of Andronicus, who was eminent for his riches and excellent qualities, was born at Tauromenium in Sicily, and flourished in the time of Agathocles. He wrote several books, and among the rest an history of his own country; but they are all lost.

TIMÆUS, a famous Pythagorean philosopher, was born at Locres in Italy, and lived before Plato. There is still extant a small treatise of his on Nature and the Soul of the World, written in the Doric dialect. This treatise, which is to be found in the works of Plato, furnished that great philosopher with the subject of his treatise intitled *Timæus*.

TINNING, the covering or lining of any thing with melted tin, or with tin reduced to a very fine leaf. Looking-glasses are foliated or *tinned* with thin plates of beaten tin, by a process described under the title FOLIATING, *Encycl.*

Kettles, sauce-pans, and other kitchen utensils, which are usually made of copper, are tinned by the following process: The surface to be tinned, if of new copper, should first be cleaned or scoured with salt and sulphuric acid (vitriolic acid) diluted with water. This, however, is not always done; some workmen contenting themselves with scouring it with sand perfectly dry, or with scales of iron. Powdered rosin is then strewed over it; and when the vessel or utensil is considerably heated, melted tin is poured into it, and rubbed with flax coiled hard over the surface to be coated. This tin may be either pure, such as that known by the name of *grain-tin*; or a composition consisting of two parts of tin and one of lead. For very obvious reasons, we should certainly prefer the pure tin; but the generality of workmen give the preference to the composition, because the surface coated with it appears more brilliant. The tin is not always put into the vessel in a liquid state; for some workmen strew it in small pieces over the surface to be coated, and then heat the vessel till the tin melt, when they rub it as formerly.

In tinning old vessels which have been tinned before, the process is somewhat different. In these cases, the surface is first scraped with an instrument proper for the purpose, or scoured with the scales of iron, which may be always found in a blacksmith's shop: it is then strewed over with sal ammoniac in powder, instead of rosin, or an infusion of sal ammoniac in stale urine is boiled in it till the urine be evaporated, and it is then tinned with pure tin; the composition of tin and lead being in this case never used. The tin, while liquid, is rubbed into the surface with a piece of sal ammoniac, instead of a bundle of flax. When iron vessels are to be tinned, they are first cleaned with muriatic acid, after which the process is the same as in the tinning of old copper.

In the year 1785, Mr John Poulain of Mortlake, Surrey, obtained a patent for the discovery of a new composition for tinning vessels, especially such as are used for culinary purposes. This composition consists of grain-tin one pound, good malleable iron one ounce and a half, platinum one drachm, silver one pennyweight, gold three grains: the whole must be well fused together in a crucible, with one ounce of pounded borax, and two ounces of pounded glass, and then cast in small ingots. The composition, to be fit for use, must be heated and put in a metal mortar, also heated over a fire, and well pounded with a heated metal pestle; when it is well pounded, make an ingot of it, by putting it on the fire in a mould made of iron plate, in which mould the composition must be well stirred and let to cool; then it is fit for use. To apply the composition, first tin the utensil or vessel with grain-tin and sal ammoniac, as is usually done in the common way of tinning; clean well the tinned part of the metal utensil or vessel, and then apply a coat of the composition with sal ammoniac, as is usually done in the common way of tinning; and when the composition is well spread, let it cool; then make it a little red-hot in all its parts, to neal it, and plunge the metal utensil or vessel, while yet hot, in cold water; then, with a sharp scraper, scrape and rub off the rough or grumous particles of the composition applied on the metal utensil or vessel, and scour it well with sand. The same operation must be repeated for every coat of the composition that is applied; two coats of the composition are quite sufficient for culinary utensils or vessels, and a thin coat of grain-tin may be applied over the last coat of the composition, to smooth it. The author adds, that his composition may be employed for covering or plating the surfaces of all materials made of copper, brass, iron, and other metals or mixtures of metals, and that it should be applied with a charcoal fire in preference to any other fire. All this may be true, and it may be a very valuable coating to copper; but the scarcity, high price, and infusibility of platinum, must for ever prevent it from coming into very general use.—We think that even the ENAMELLING *of Vessels for the Kitchen* must be more common. See that article in this *Supplement*.

The following process is less expensive, whilst the coating given by it is exceedingly durable, adds strength to the copper vessel, and secures it much longer than the common tinning from the action of acids:

When the vessel has been prepared and cleaned in the usual manner, it must be roughened on the inside by being beat on a rough anvil, in order that the tinning may hold better, and be more intimately connected with the copper. The process of tinning must then be begun with perfectly pure grained tin, having an addition of sal ammoniac instead of the common colophonium or resin. Over this tinning, which must cover the copper in an even and uniform manner throughout, a second harder coat must be applied, as the first forms only a kind of medium for connecting the second with the copper. For this second tinning you employ pure grained tin mixed with zinc in the proportion of two to three, which must be applied also with sal ammoniac smooth and even, so that the lower stratum may be entirely covered with it. This coating, which, by the addition of the zinc, becomes pretty hard and solid, is then to be hammered with a smoothing hammer, after it has been properly rubbed and scoured with chalk and water; by which means it becomes more solid, and acquires a smooth compact surface.

Vessels and utensils may be tinned in this manner on both sides. In this case, after being exposed to a sufficient heat, they must be dipped in the fluid tin, by which means both sides will be tinned at the same time.

As this tinning is exceedingly durable, and has a beautiful colour, which it always retains, it may be employed for various kinds of metal instruments and vessels which it may be necessary to secure from rust.

TINPLATE, called in Scotland *White-iron*, is a thin plate of iron covered with tin, to which it is united by chemical affinity. See CHEMISTRY, n° 122. *Suppl.*

TIPRA, the name of certain mountainous districts to the eastward of Bengal, inhabited by a people of very singular manners. As every thing which contributes a single fact to the history of human nature is interesting to the philosopher, the reader will be pleased with the following account of the religion, laws, and manners of these people, taken from the 2d volume of the *Asiatic Researches*.

Though they acknowledge one Creator of the universe, to whom they give the name of PA'TIYA'N, they believe that a deity exists in every tree, that the sun and moon are gods, and that whenever they worship those

subordinate divinities Pátiyán is placed. This is very similar to the religious creed of ancient Greece and Rome, differing only with respect to creation, which, in the proper sense of the word, the Greeks and Romans seem not to have admitted.

If any one of these mountaineers, called in the memoir Cucis, put another to death, the chief of the tribe, or other persons who bear no relation to the deceased, have no concern in punishing the murderer; but if the murdered person have a brother or other heir, he may take blood for blood; nor has any man whatever a right to prevent or oppose such retaliation.

When a man is detected in the commission of theft or other atrocious offence, the chieftain causes a recompense to be given to the complainant, and reconciles both parties; but the chief himself receives a customary fine, and each party gives a feast of pork or other meat to the people of his respective tribe.

In ancient times, it was not a custom among them to cut off the heads of the women whom they found in the habitations of their enemies; but it happened once that a woman asked another, why she came so late to her business of sowing grain? she answered, that her husband was gone to battle, and that the necessity of preparing food and other things for him had occasioned her delay. This answer was overheard by a man at enmity with her husband; and he was filled with resentment against her, considering, that as she had prepared food for her husband for the purpose of sending him to battle against his tribe, so in general, if women were not to remain at home, their husbands could not be supplied with provision, and consequently could not make war with advantage From that time it became a constant practice to cut off the heads of the enemy's women, especially if they happen to be pregnant, and therefore confined to their houses; and this barbarity is carried so far, that if a Cuci assail the house of an enemy, and kill a woman with child, so that he may bring two heads, he acquires honour and celebrity in his tribe, as the destroyer of two foes at once.

As to the marriages of this wild nation, when a rich man has made a contract of marriage, he gives four or five head of *gayáls* (the cattle of the mountains) to the father and mother of the bride, whom he carries to his own house: Her parents then kill the *gayáls*; and having prepared fermented liquors and boiled rice with other eatables, invite the father, mother, brethren, and kindred of the bridegroom to a nuptial entertainment. When a man of small property is inclined to marry, and a mutual agreement is made, a similar method is followed in a lower degree; and a man may marry any woman except his own mother. If a married couple live cordially together, and have a son, the wife is fixed and irremoveable; but if they have no son, and especially if they live together on bad terms, the husband may divorce his wife, and marry another woman.

They have no idea of heaven or hell, the reward of good, or the punishment of bad, actions; but they profess a belief, that when a person dies, a certain spirit comes and seizes his soul, which he carries away; and that whatever the spirit promises to give at the instant when the body dies, will be found and enjoyed by the dead; but that if any one should take up the corse and carry it off, he would not find the treasure.

The food of this people consists of elephants, hogs, deer, and other animals; of which if they find the carcases or limbs in the forests, they dry them, and eat them occasionally.

When they have resolved on war, they send spies, before hostilities are begun, to learn the stations and strength of the enemy, and the condition of the roads; after which they march in the night, and two or three hours before daylight make a sudden assault with swords, lances, and arrows: if their enemies are compelled to abandon their station, the assailants instantly put to death all the males and females, who are left behind, and strip the houses of all their furniture; but should their adversaries, having gained intelligence of the intended assault, be resolute enough to meet them in battle, and should they find themselves overmatched, they speedily retreat and quietly return to their own habitations. If at any time they see a star very near the moon, they say, "to-night we shall undoubtedly be attacked by some enemy;" and they pass that night under arms with extreme vigilance. They often lie in ambush in a forest near the path, where their foes are used to pass and repass, waiting for the enemy with different sorts of weapons, and killing every man or woman who happens to pass by: in this situation, if a leech, or a worm, or a snake, should bite one of them, he bears the pain in perfect silence; and whoever can bring home the head of an enemy, which he has cut off, is sure to be distinguished and exalted in his nation. When two hostile tribes appear to have equal force in battle, and neither has hopes of putting the other to flight, they make a signal of pacific intentions, and, sending agents reciprocally, soon conclude a treaty; after which they kill several head of *gayáls*, and feast on their flesh, calling on the sun and moon to bear witness of the pacification: but if one side, unable to resist the enemy, be thrown into disorder, the vanquished tribe is considered as tributary to the victors; who every year receive from them a certain number of *gayáls*, wooden dishes, weapons, and other acknowledgments of vassalage. Before they go to battle, they put a quantity of roasted *álus* (esculent roots like potatoes), and paste of riceflour, into the hollow of bamboos, and add to them a provision of dry rice with some leathern bags full of liquor: then they assemble, and march with such celerity, that in one day they perform a journey ordinarily made by letter-carriers in three or four days, since they have not the trouble and delay of dressing victuals. When they reach the place to be attacked, they surround it in the night, and at early dawn enter it, putting to death both young and old, women and children, except such as they choose to bring away captive: they put the heads, which they cut off, into leathern bags; and if the blood of their enemies be on their hands, they take care not to wash it off When after this slaughter they take their own food, they thrust a part of what they eat into the mouths of the heads which they have brought away, saying to each of them, "Eat, quench thy thirst, and satisfy thy appetite; as thou hast been slain by my hand, so may thy kinsmen be slain by my kinsmen!" During their journey, they have usually two such meals; and every watch, or two watches, they send intelligence of their proceedings to their families. When any one of them sends word that he has cut off the head of an enemy, the people of his family, whatever be their age or sex, express great de-

Tipra.

light, making caps and ornaments of red and black ropes; then filling some large vessels with fermented liquors, and decking themselves with all the trinkets they possess, they go forth to meet the conqueror, blowing large shells, and striking plates of metal, with other rude instruments of music. When both parties are met, they show extravagant joy, men and women dancing and singing together; and if a married man has brought an enemy's head, his wife wears a head dress with gay ornaments, the husband and wife alternately pour fermented liquor into each other's mouths, and she washes his bloody hands with the same liquor which they are drinking. Thus they go revelling, with excessive merriment, to their place of abode; and having piled up the heads of their enemies in the court yard of their chieftain's house, they sing and dance round the pile; after which they kill some *gayáls* and hogs with their spears; and having boiled the flesh, make a feast on it, and drink the fermented liquor. The richer men of this race fasten the heads of their foes on a bamboo, and fix it on the graves of their parents, by which act they acquire great reputation. He who brings back the head of a slaughtered enemy, receives presents from the wealthy of cattle and spirituous liquor; and if any captives are brought alive, it is the prerogative of those chieftains, who were not in the campaign, to strike off the heads of the captives. Their weapons are made by particular tribes; for some of them are unable to fabricate instruments of war.

In regard to their civil institutions; the whole management of their household affairs belongs to the women; while the men are employed in clearing forests, building huts, cultivating land, making war, or hunting game and wild beasts. Five days (they never reckon by months or years) after the birth of a male child, and three days after that of a female, they entertain their family and kinsmen with boiled rice and fermented liquor; and the parents of the child partake of the feast. They begin the ceremony with fixing a pole in the court yard; and then killing a *gayál* or a hog with a lance, they consecrate it to their deity; after which all the party eat the flesh and drink liquor, closing the day with a dance and with songs. If any one among them be so deformed, by nature or by accident, as to be unfit for the propagation of his species, he gives up all thought of keeping house, and begs for his subsistence, like a religious mendicant, from door to door, continually dancing and singing. When such a person goes to the house of a rich and liberal man, the owner of the house usually strings together a number of red and white stones, and fixes one end of the string on a long cane, so that the other end may hang down to the ground; then, paying a kind of superstitious homage to the pebbles, he gives alms to the beggar; after which he kills a *gayál* and a hog, and some other quadrupeds, and invites his tribe to a feast: the giver of such an entertainment acquires extraordinary fame in the nation, and all unite in applauding him with every token of honour and reverence.

When a *Cúci* dies, all his kinsmen join in killing a hog and a *gayál*; and, having boiled the meat, pour some liquor into the mouth of the deceased, round whose body they twist a piece of cloth by way of shroud: all of them taste the same liquor as an offering to his soul; and this ceremony they repeat at intervals for several days. Then they lay the body on a stage, and kindling a fire under it, pierce it with a spit and dry it; when it is perfectly dried, they cover it with two or three folds of cloth, and, enclosing it in a little case within a chest, bury it under ground. All the fruits and flowers that they gather within a year after the burial they scatter on the grave of the deceased: but some bury their dead in a different manner; covering them first with a shroud, then with a mat of woven reeds, and hanging them on a high tree. Some, when the flesh is decayed, wash the bones, and keep them dry in a bowl, which they open on every sudden emergence; and, fancying themselves at a consultation with the bones, pursue whatever measures they think proper; alleging that they act by the command of their departed parents and kinsmen. A widow is obliged to remain a whole year near the grave of her husband; where her family bring her food: if she die within the year, they mourn for her; if she live, they carry her back to her house, where all her relations are entertained with the usual feast of the *Cúcis*.

If the deceased leave three sons, the eldest and the youngest share all his property; but the middle son takes nothing: if he have no sons, his estate goes to his brothers; and if he have no brothers, it escheats to the chief of the tribe.

Tiresias, Tisri.

TIRESIAS, a famous soothsayer of antiquity, was the son of Everes and the nymph Chariclo. Pherecydes says, that Minerva being accidentally seen by Tiresias, as she was bathing with Chariclo in the fountain of Hippocrene, the goddess was enraged, and declared that he should see nothing more: on which he instantly lost his sight; but afterwards received from the goddess superior endowments. Others say, that Juno struck him stone-blind for deciding a case between Jupiter and her, to her dissatisfaction, for which Jupiter gave him the faculty of divination: He was the most celebrated prophet in the Grecian annals. Ulysses is ordered by Circe to consult him in the shades.

> There seek the Theban bard depriv'd of sight,
> Within irradiate with prophetic light.

But, besides the honour done to him by Homer, Sophocles makes him act a venerable and capital part in his tragedy of Oedipus. Callimachus ascribes to Minerva the gift of his superior endowments; the pre-eminence of his knowledge is likewise mentioned by Tully in his first book of Divination. And not only Tiresias is celebrated by Diodorus Siculus, but his daughter Daphne, who, like her father, was gifted with a prophetic spirit, and was appointed priestess at Delphos. She wrote many oracles in verse, from whence Homer was reported to have taken several lines, which he interwove in his poems. As she was often seized with a divine fury, she acquired the title of *sibyl*, which signifies "enthusiast" She is the first on whom it was bestowed: in aftertimes this denomination was given to several other females that were supposed to be inspired, and who uttered and wrote their predictions in verse; which verse being sung, their function may be justly said to unite the priesthood with prophecy, poetry, and music.

TISRI or TIZRI, in chronology, the first Hebrew month of the civil year, and the 7th of the ecclesiastical or sacred year. It answered to part of our September and October.

TITHING-MEN,

TITHING-MEN, are now a kind of petty constables, elected by parishes, and sworn in their offices in the court leet, and sometimes by justices of the peace, &c. There is frequently a tithing-man in the same town with a constable, who is, as it were, a deputy to execute the office in the constable's absence; but there are some things which a constable has power to do, that tithing-men and head-boroughs cannot intermeddle with. When there is no constable of a parish, his office and the authority of a tithing man seems to be all one under another name.

TITHONUS, in fabulous history, the son of Laomedon king of Troy, and the brother of Priamus; was beloved by Aurora, who carried him to Delos, thence to Ethiopia, and at last to heaven, where she prevailed on the Destinies to bestow upon him the gift of immortality; but forgot to add that of youth, which could only render the present valuable. At length Tithonus grew so old that he was obliged to be rocked to sleep like an infant; when Aurora, not being able to put an end to his misery by death, transformed him into a grasshopper; which renews its youth by casting his skin, and in its chirping retains the loquacity of old age.

TITLE FOR ORDERS, in the church of England, is an assurance of being employed and maintained as an officiating clergyman in some cathedral or parochial church, or other place of Divine worship. And, by the 33*d Canon*, "no one is to be ordained but in order to be a curate or incumbent, or to have some minister's place in some church, or except he be fellow, conduct, or chaplain, in some college in one of the universities, or be master of arts of five years standing, and live there at his own cost." By the same canon, the bishop who ordains a clerk without title, is bound to keep him till he prefer him to some ecclesiastical living.

TOD OF WOOL, is mentioned in the statute 12 Carol. II. c. 32. as a weight containing 2 stone, or 28 pounds.

TOMBUCTOO, a large city in North Africa, and capital of a kingdom of the same name. It has for some years past been the great object of European research, being one of the principal marts for that extensive commerce which the Moors carry on with the Negroes. The hopes of acquiring wealth in this pursuit, and zeal for propagating their religion, have filled this extensive city with Moors and Mahomedan converts; the king himself, and all the chief officers of state are Moors; and they are said to be more severe and intolerant in their principles than any other of the Moorish tribes in this part of Africa. Mr Park was informed, by a venerable old Negro, that when he first visited Tombuctoo, he took up his lodging at a sort of public inn, the landlord of which, when he conducted him into his hut, spread a mat on the floor, and laid a rope upon it; saying, "if you are a Mussulman, you are my friend, sit down; but if you are a Kafir, you are my slave; and with this rope I will lead you to market." The reigning sovereign of Tombuctoo, when Mr Park was in Africa, was named *Abu Abrahima*. He was reported to possess immense riches, and his wives and concubines were said to be clothed in silk, and the chief officers of state live in considerable splendour. The whole expence of his government is defrayed by a tax upon merchandize, which is collected at the gates of the city.

Of that city very little is known with accuracy, as it has never been visited by any European. It is the largest on the Niger, Houssa only excepted; and probably contains from 60,000 to 80,000 inhabitants. In some of the Gazetteers, its houses are said to be built in the form of bells; but they are probably such buildings as those of SEGO, which see in this *Supplement*. Tombuctoo, according to Major Rennel, is in 16′ 30′ N. Lat. and 1° 33′ E. Long. from Greenwich.

TOMSOOK, in the language of Bengal, a bond.

TOOTH-ACHE, a well known excruciating pain (see *Encycl.*), for the alleviation, and even the cure of which, many specifics have been offered to the public. Of one of the most extraordinary of these, there is an account, in a small work published at Florence in 1794, by professor Gerbi, who gives the description of an insect, a kind of *curculio*, which, from its property of allaying the tooth-ache, has received the epithet of *antiodontalgicus*, and which is found on a species of thistle, *carduus spinosissimus*. The flowers of this thistle, when analysed, gave the acid of galls, the muriatic acid, oxalat of lime, extractive matter, and a very little resin. On the bottom of the calyx, which supports the flowers, there are often found excrescences like the gall-nut, which are at first spheroidal, afterwards cylindric, and at length assume the figure of two hemispheres: they consist of the like component parts with the flowers, but contain more resin, and far more oxalat of lime; as the gall apple of the oak, according to the experiments of M. Branchi, which are here mentioned, contains more of the acid of galls than the bark and other parts of the oak, in which he could discover no sulphuric acid. The insect, according to the author's observations, eats not only the parenchyma, but also the vessels and fibres of the leaves. The egg, before the worm makes its appearance, is nourished by the sap of the plant, and of the above excrescences, in which it resides, by means of the attractive power that the egg possesses for certain vegetable juices and substances. The excrescences arise by the accumulation of a solid substance, which is precipitated from the nourishing juices of the thistle, diminished by nourishing the egg and the worm. This insect, the eggs of which are deposited in these excrescences, is, together with the *curculio* of the centaury, a new species. It is of a longish figure; covered below with short yellow hair, and above with golden yellow velvety spots. Its corslet is variegated with specks; and the covering of its wings with specks and stripes. It has a short proboscis, and shews some likeness to the *curculio villosus* of Geoffroy. Its larva represents a sort of ichneumon. By chemical analysis it exhibits some traces of common salt; by distillation with a strong dry heat, some volatile lixivious salts; and it contains, besides these, some gelatinous, and a little sebaceous and slimy extractive matter. If about a dozen or fifteen of these insects, when in the state of larva, or even when come to perfection, be bruised and rubbed slowly between the fore-finger and the thumb, until they have lost their moisture, and if the painful tooth, where it is hollow, be touched with that finger, the pain ceases, sometimes instantaneously. This power or property the finger will retain for a year, even though it be often washed and used. A piece of shamoy leather will serve equally well with the finger. Of 629 experiments, 401 were attended with complete success. In

Tooth-ache || Torelli.

two of these cases, the hollow teeth arose from some fault in the juices: in the rest they were merely local. If the gums are inflamed, the remedy is of no avail.

To the truth of this tale the reader will give what credit he pleases; but it is surely very difficult to believe, that a living finger, continually perspiring, can retain for a year the moisture imbibed from this insect. But it seems there are other insects which have the property of curing the tooth ache; such as the *carabus chrysocephalus* of Rossi; the *carabus ferrugineus* of Fabricius; the *coccinella septem punctata* (the lady bird); the *chrysomela populi*, and the *chrysomela sanguinolenta*. It would appear, therefore, that this property belongs to various kinds of the *coleoptera*.

The idea of these insects being endowed with the property of curing the tooth-ache is not confined to Italy; for Dr Hirsch, dentist to the court of Weimar, asserts (*Verkundiger*, September 24, 1798) that he employed them with the happiest effect, except in some cases where his patients were females. He says, that he took that small insect, found commonly among corn, *coccinella septem punctata*, and bruised it between his fingers. He then rubbed the fingers with which he had bruised it, till they became warm at the points, and touched with them the unsound parts of the gums, as well as the diseased tooth. Dr Hirsch adds, that he made the same experiment a few days after with equal success, though he had not bruised a new insect with his fingers. He seems to think that, to insure the efficacy of the process, the insect should be alive; because, when dead, its internal parts, in which he presumes the virtue chiefly resides, become dried up, leaving only the wings and an empty shell; and therefore proposes to physicians to turn their attention to the finding out of some method for preserving the virtue of the insect, so that its efficacy may be in full vigour throughout the year.

Besides these beetles, charcoal has been recommended as an anodyne in the tooth-ache; but whether it operates merely by filling the hollow of the tooth, and thereby preventing the access of atmospheric air to the nerve, or by any of its singular and hitherto unknown qualities, seems not to have been well ascertained.

TOR, a town of Asia, in Arabia Petræa, seated on the Red Sea, with a good harbour, defended by a castle. There is a handsome Greek convent, in whose garden are fountains of bitter water, which they pretend are those rendered sweet by Moses, by throwing a piece of wood into them. Some think that this town is the ancient Elana. E. Long. 31. 25. N. Lat. 28. 0.

TORELLI (Joseph), was born at Verona on the 4th of November 1721. His father Lucas Torelli, who was a merchant, dying while young Torelli was but an infant, he was left entirely to the care of his mother Antonia Albertini, a Venetian lady of an excellent character. After receiving the first rudiments of learning, he was placed under the Ballerini, who, observing the genius of the boy, prevailed upon his mother to send him to complete his education at Patavia. Here he spent four years entirely devoted to study, all his other pas- orbed by his thirst for knowledge.

l innocence of his life, and the prudenc and gravity of his conduct, soon attracting the atter tion of his masters, they not only commended him wi eagerness, but performed to him the part of parents, conversed with him familiarly about their respective sciences, and read over to him privately the lectures which they had to deliver. This was the case particularly with Hercules Dondinus, under whom Torelli studied jurisprudence. But he by no means confined himself to that science alone. The knowledge which he acquired was so general, that upon whatever subject the conversation happened to turn, he delivered his sentiments upon it in such a manner that one would have thought he had bestowed upon it his whole attention.

Torelli.

After receiving the degree of Doctor, he returned home to the enjoyment of a considerable fortune; which putting it into his power to choose his own mode of living, he determined to devote himself entirely to literary pursuits. He resolved, however, not to cultivate one particular branch to the exclusion of every oth but to make him self master of one thing after another, as his humour inclined him; and he was particularly attentive to lay an accurate and solid foundation. Tho' he declined practising as a lawyer, he did not, on that account, relinquish the study of law. The Hebrew, Greek, Latin, and Italian languages, occupied much of his time. His object was to understand accurately the two first, and to be able to write and speak the two last with propriety and elegance. Besides these languages, he learned French, Spanish, and English. On the last, in particular, he bestowed uncommon pains; for he was peculiarly attached to the British nation, and to British writers, whom he perused with the greatest attention; not merely to acquire the language, but to imbibe also that force and loftiness of sentiment for which they are so remarkable. Nay he even began an Italian translation of Paradise Lo

He likewise made himself acquainted with ethics, metaphysics, and polemic divinity; to which last subject he was induced to attention by the custom of his country. With an t history he was very familiarly acquainted, calli in to his assistance, while engaged in that study, aids of chronology, geography, and criticism. Thi art, indeed, by means of which what is counterfei ay be distinguished from what is genuine, what is erpolated from what is uncorrupted, and what is ellent from what is faulty, he carried about wit m as his counsellor and his guide on on all occasio f *music* he studied with attention, pre-

The theo owerful airs which make their way into ferring tho rouse the passions at the pleasure of the the soul, His knowledge of *pictures* was held in high musician by the artists themselves, who were accustom estimati his opinion concerning the fidelity of the ded to e harmony of colours, the value of the picture, sign, e name of the painter. He himself had a collecand not remarkably splendid indeed, but exceedingly tio chosen. *Architecture* he studied with still greater w ention, because he considered it as of more real utili- a

Nor did he neglect the pursuits of the *antiquarian*, ut made himself familiarly acquainted with coins, gems, medals, engravings, antique vessels, and monuments. Indeed scarce any monumental ins were engraved at Verona which he had not ...... composed or corrected. With the *antiquities* of his own country he was so intimately acquainted, that every person of emi- nence,

nence, who visited Verona, took care to have him in their company when they examined the curiosities of the city.

But these pursuits he considered merely as amusements; mathematics and the belles lettres were his serious studies. These studies are, in general, considered as incompatible; but Torelli was one of the few who could combine the gravity of the mathematician with the amenity of the muses and graces, and who handle the compass and the plectrum with equal skill. Of his progress in mathematics, several of his treatises, and especially his edition of Archimedes, published since his death by the university of Oxford, are sufficient proofs. Nor was his progress in the more pleasing parts of literature less distinguished. In both these studies he was partial to the ancients and was particularly hostile to the poetry and the literary innovations of the French.

Nothing could be purer or more elegant than his Latin style, which he had acquired at the expence of much time and labour. His Latin translation of Archimedes is a sufficient proof of this, and is indeed really wonderful, if we consider that the Romans, being far inferior to the Greeks in mathematical knowledge, their language was of necessity destitute of many necessary words and phrases. He wrote the Italian language with the classic elegance of the 14th and 15th centuries. Witness his different works in that language, both in prose and verse. H translated the whole of Æsop's Fables into Latin, and Theocritus, the *Epithalamium* of Catullus, and the *comed* of Plautus, called *Pseudolus*, into Italian verse. The wo first books of the Æneid were also translated by hi with such exactness, and so much in the style of the iginal, that they may well pass for the work of Virgil mself.

His life, like his studies, as drawn after the model of the ancient sages. Fr l, temperate, modest, he exhibited a striking contrast the luxurious manners of his age. In religion he ac d strictly, though not superstitiously, to the opinion f his ancestors. He was firm to his resolutions, but foolishly obstinate; and so strict an observer of eq that his probity would have remained inviolate, ev hough there had been no law to bind him to justice. e never married, that he might have leisure to devote self, with less interruption to his favourite studies. very one readily found admission to him, and no ma t him without being both pleased and instructed; h was the sweetness of his temper, and the readine ith which he communicated information. He adhere ith great constancy to his friendships. This was part rly exemplified in the case of Clemens Sibiliatus, w as favoured the world with the life of Torelli. W him he kept up the closest connection from a school- till the day of his death. He was peculiarly attache kewise to many men of distinction, both in Italy and ritain. He died in August 1781, in the 70th yea f his age.

The following is a complete list of his works, his e tion of Archimedes excepted, which was not publishe till after his death:

1. "Lucubratio Academica, sivi Somnium Jacobi Pindemontii, &c." Patavii, 1743.—2. "Animadversiones in Hebraicum Exodi Librum et in Græcum lxx Interpretationem;" Veronæ, 1744.—3. "De principe Gulæ incommodo, ejusque remedio, Libri duo;" Coloniæ Agrippinæ, 1744.—4. "De Probabili Vitæ Morumque Regula;" Coloniæ, 1747.—5. "Li due primi Canti dell' Iliade (di Scipione Maffei) e li due primi dell' Eneide di Giuseppe Torelli tradotti in versi Italiani;" Verona, 1749.—6. "Gli stessi due canti dell' Eneide ristampati soli lo stesso anno per lo stesso Ramanzini"—7. "Scala de Meriti a capo d'anno Trattato Geometrico;" Verona, 1751.—8. "De Nihilo Geometrico, lib. 2.;" Veronæ, 1758.—9. "Lettera intorno a due passi del Purgatorio di Dante Alighiero;" *ib* 1760.—10. "Della Denominazione del corrente anno volgarmente detto 1760 in Bologna per Lelio della Volpe." 11. "Il pseudolo. Comedia. &c e si aggiunge la traduzione d'alcuni Idilli di Teocrito e di Mosco;" Firenze, 1765—12. "Inno a Maria Virgine nella Festivita della sua Concezione;" Verona, 1766.—13. "Lettera a Miladi Vaing-Reit premessa al libro che ha per titalo xii. lettere Inglesi, con altra lettera all'autore della suddetta;" Verona, 1767.—14. "Elegia di Tommaso Gray, Poeta Inglese, in un Cimetero Campestre in versi Italiani rimati;" Verona, 1767.—15. "Geometrica;" Veronæ, 1769—16. "Demonstratio antiqui Theorematis de motuum commixtione;" Veronæ, 1774.—17. "Lettera supra Dante contro il Signor di Voltaire;" Verona, 1781.—18. "Poemetto di Catullo su le Nozze di Peleo e Tetite, ed un Epitalamio dello stesso;" 1781.—19. "Œsopi Fabulæ."—20. "Teocrito tradotto, in versi Toscani."—21. "Elementi d'Euclide tradotti nell'idioma Italiano."—22. "Elementorum Prospectivæ, libri duo."

TORPEDO, or CRAMP-FISH, has been described under the generic title RAJA; and an attempt made to explain its electrical phenomena in the article ELECTRICITY, n° 258, &c. (Both these articles are in the *Encyclopædia*). From some late discoveries, however, of Volta and others, the shock given by the torpedo appears much more analogous to the shock of GALVANISM than to that of common electricity; and even the electrical organs of the fish seem to resemble the apparatus with which those discoveries in galvanism were made.

In the 63d volume of the Philosophical Transactions, Mr Hunter describes the electric organ of the torpedo as consisting of a number of columns, varying in their length from an inch and a half to a quarter of an inch, with diameters about two-tenths of an inch. The number of columns in each organ of the torpedo which he presented to the Royal Society was about 470; but in a very large torpedo which he dissected, the number of columns in one organ was 1182. These columns were composed of films parallel to the base of each; and the distance between each partition of the columns was $\frac{1}{150}$th of an inch. From these facts, the reader will find the anomalies of torpedinal electricity (supposing it the same with common electricity) accounted for in a very ingenious and philosophical manner by Mr Nicholson, at p. 358 of the first volume of his valuable Journal. We pass on, however, to point out the resemblance between it and the lately discovered phenomena in galvanism.

Take any number of plates of copper, or, which is better, of silver, and an equal number of tin, or, which is much better, of zinc, and a like number of discs, or pieces

Torpedo.

pieces of card, or leather, or cloth (A), or any porous subſtance capable of retaining moiſture. Let theſe laſt be ſoaked in pure water, or, which is better, ſalt and water, or alkaline leys. The ſilver or copper may be pieces of money. Build up a pile of theſe pieces; namely, a piece of ſilver, a piece of zinc, and a piece of wet card: then another piece of ſilver, a piece of zinc, and a piece of wet card: and ſo forth, in the ſame order (or any other order, provided the pieces ſucceed each other in their turn), till the whole number intended to be made uſe of is builded up. The inſtrument is then completed.

In this ſtate it will afford a perpetual current of the galvanic influence through any conductor communicating between its upper and lower plates; and if this conductor be an animal, it will receive an electrical ſhock as often as the touch is made, by which the circuit is completed. Thus if one hand be applied to the lower plate, and the other to the upper, the operator will receive a ſhock, and that as often as he pleaſes to lift his finger and put it down again.

This ſhock reſembles the weak charge of a battery of immenſe ſurface; and its intenſity is ſo low that it cannot make its way through the dry ſkin. It is therefore neceſſary that a large ſurface of each hand ſhould be well wetted, and a piece of metal be graſped in each, in order to make the touch; or elſe that the two extremities of the pile ſhould communicate with ſeparate veſſels of water, in which the hands may be plunged.

The commotion is ſtronger the more numerous the pieces. Twenty pieces will give a ſhock in the arms, if the above precautions be attended to. One hundred pieces may be felt to the ſhoulders. The current acts on the animal ſyſtem while the circuit is complete, as well as during the inſtant of commotion, and the action is abominably painful at any place where the ſkin is broken.

That this influence, whatever it may be, has a ſtriking reſemblance to the repeated ſhocks given by the torpedo, is obvious; but what it really is in itſelf muſt be aſcertained, if it can be aſcertained at all, by future experiments. Mr Nicholſon indeed, from whoſe Journal we have taken this account of Volta's apparatus and its effects, ſeems confident that theſe effects proceed from an electrical ſtream or current; but this mode of operation is quite foreign from all the laws of electricity known to us. The galvanic influence in this apparatus appears to move perpetually in a circle; to which we are acquainted with no fact in electricity that is at all ſimilar. Galvaniſm, too, ſeems capable of accumulation, even while ſurrounded by conducting ſubſtances, which is quite inconſiſtent with all that we *diſtinctly* know of electricity and its laws.

That the energy of the apparatus, however, is the effect of an electric ſtream or current, our ingenious author thinks proved by the condenſer with which Sig. Volta aſcertained the kind of the electricity, and obtained its ſpark. He finds the action ſtrongeſt, or moſt pungent, on wounds on the minus ſide of the apparatus, or where the wounds give out electricity; a fact alſo obſervable in the common electric ſpark.

The theory of the learned inventor ſeems to be, that it is a property of ſuch bodies as differ in their power of conducting electricity, that when they are brought into contact they will occaſion a ſtream of the electric matter. So that if zinc and ſilver be made to communicate immediately by contact, there will be a place of good conducting energy; and if they be made to communicate mediately by means of water, there will be a place of inferior conducting energy: and wherever this happens, there will be a ſtream or current produced in the general ſtock of electricity. This is not deduced as the conſequence of other more ſimple facts; but is laid down as a general or ſimple principle grounded on the phenomena. If ſo, is it not a *petitio principii?* That ſuch bodies as zinc and ſilver, when properly diſpoſed, produce a ſtream or current, or ſomething analogous to a ſtream or current, in the galvanic fluid, follows indeed indiſputably from the phenomena; but it by no means follows from the ſame phenomena that galvaniſm is electricity; for electricity ſeems ſubject to different laws. See ELECTRICITY and THUNDER, both in this *Supplement*.

It muſt be acknowledged that the diſcovery of the galvanic ſhock and ſpark, and of the apparent exiſtence of two oppoſite ſtates of galvaniſm correſponding to poſitive and negative electricity, conſiderably increaſe the analogy; which, in the article GALVANISM, *Suppl.* we have admitted to be very ſtriking: but ſuppoſing no fallacy in any of Volta's experiments, we do not think that theſe diſcoveries amount to any thing like a demonſtration of the concluſions which have been drawn from them. It is by no means certain that light is eſſentially connected with the electric fluid; for we know that it is not eſſentially connected with heat: (See *THERMOMETRICAL Spectrum*, in this *Suppl.*) The flaſh, for example, of lightning may be merely an extrication of light, in conſequence of the action of electricity upon the atmoſphere in its paſſage, or on the bodies upon which it impinges; and there are many inſtances of a ſimilar extrication, as in the colliſion of two pieces of flint, where neither electricity nor galvaniſm were ever ſuſpected to have any ſhare in producing the phenomenon. Why may not the progreſs of the galvanic fluid have a ſimilar effect in this inſtance with that of electricity, though the two fluids be eſſentially different between themſelves? But we have more to ſay on this ſubject.

Meſſrs Nicholſon and Carliſle conſtructed an apparatus ſimilar to that of Volta, which gave them a ſhock as before deſcribed, and a very acute ſenſation wherever the ſkin was broken. Their firſt reſearch was directed to aſcertain that the ſhock they felt was really an electrical phenomenon. For this purpoſe the pile was placed upon Bennett's gold leaf electrometer, and a wire was then made to communicate from the top of the pile to the metallic ſtand or foot of the inſtrument; ſo that the circuit of the ſhock would have been thro' the leaves, if they had diverged; but no ſigns of electricity appeared. Recourſe was then had to the revolving doubler; of which the reader will find an account in our Supplementary article ELECTRICITY,

(A) Woollen or linen cloth appear to be more durable, and more ſpeedily ſoaked, than card.

n° 202. The doubler had been previously cleared of electricity by twenty turns in connection with the earth. The negative divergence was produced in the electrometer. Repeated experiments of this kind shewed that the silver end was in the minus, and the zinc end in the plus state.

Here a pile of 17 half crowns, with a like number of pieces of zinc, and of pasteboard soaked in salt water, though it gave a severe shock, exhibited no symptoms of electricity till assisted by the doubler. Will it be said that this arose from want of intensity in the galvanic shock? We can only reply, that a much less intense shock of electricity would have produced a sensible divergence in the instrument without the doubler. What was the cause of this difference? We have, however, no doubt but that electricity was concerned in this phenomenon, for we have shewn elsewhere (see THUNDER, *Suppl.*), that either *electricity* is produced, or the equilibrium of the electrical fluid disturbed, by every chemical solution; and we shall see immediately that chemical solutions are perpetually going on in Volta's apparatus.

Very early in the course of this experiment, the contacts being made sure by placing a drop of water upon the upper plate, Mr Carlisle observed a disengagement of gas round the touching wire. This gas, though very minute in quantity, evidently seemed to have the smell afforded by hydrogen when the wire of communication was steel. This, with some other facts, led Mr Nicholson to propose to break the circuit by the substitution of a tube of water between two wires. They therefore inserted a brass wire through each of two corks inserted in a glass tube of half an inch internal diameter. The tube was filled with New River water, and the distance between the points of the wires in the water was one inch and three quarters. This compound discharger was applied so that the external ends of its wire were in contact with the two extreme plates of a pile of 36 half crowns, with the correspondent pieces of zinc and pasteboard. A fine stream of minute bubbles immediately began to flow from the point of the lower wire in the tube which communicated with the silver, and the opposite point of the upper wire became tarnished, first deep orange, and then black. On reversing the tube, the gas came from the other point, which was now lowest; while the upper, in its turn, became tarnished and black. Reversing the tube again, the phenomena again changed their order. In this state the whole was left for two hours and a half. The upper wire gradually emitted whitish filmy clouds, which, towards the end of the process, became of a pea green colour, and hung in perpendicular threads from the extreme half inch of the wire, the water being rendered semi-opaque by what fell off, and in a great part lay, of a pale green, on the lower surface of the tube, which, in this disposition of the apparatus, was inclined about forty degrees to the horizon. The lower wire, of three quarters of an inch long, constantly emitted gas, except when another circuit, or complete wire, was applied to the apparatus; during which time the emission of gas was suspended. When this last mentioned wire was removed, the gas re-appeared as before, not instantly, but after the lapse of four beats of a half second clock standing in the room. The product of gas, during the whole two hours and a half, was two-thirtieths of a cubic inch. It was then mixed with an equal quantity of common air, and exploded by the application of a lighted waxed thread.

Messrs Nicholson and Carlisle had been led, by their reasoning on the first appearance of hydrogen, to expect a decomposition of the water; but it was with no little surprize that they found the hydrogen extricated at the contact with one wire, while the oxygen fixed itself, in combination with the other wire, at the distance of almost two inches. This new fact still remains to be explained, and seems, says Mr Nicholson, to point at some general law of the agency of electricity in chemical operations. Does it not as naturally suggest a suspicion that galvanism is not electricity; especially as we are informed, by Mr Cruickshank of Woolwich, that Messrs Nicholson and Carlisle discovered, that "galvanism decomposes water with much greater facility than electricity, and with phenomena somewhat different?" What the particular differences are, he does not say; but we learn from Mr Nicholson himself, that from the general tenor of his experiments, it appears to be established, that the decomposition of water by galvanism is more effectual the less the distance is between the wires, but that it ceases altogether when the wires are in contact.

Mr Nicholson concludes his memoir with mentioning concisely the effects of a pile of 100 half crowns, and a chemical incident, which appears to be the most remarkable of those which he has yet observed.

The pile was set up with pieces of green woollen cloth soaked in salt water. It gave severe shocks, which were felt as high as the shoulders. The transition was much less forcible through a number of persons, but it was very perceptible through nine. The spark was frequently visible when the discharge was made in the dark, and a gleam of light was also, in some instances, seen about the middle of the column at the instant of the explosion. The assistants were of opinion that they heard the snap.

The extrication of the gases was rapid and plentiful by means of this apparatus. When copper wires were used for the broken circuit, with muriatic acid diluted with 100 parts of water in the tube, no gas, nor the least circulation of the fluid was perceived, when the distance of the wires was two inches. A short tube, with two copper wires very near each other in common water, was made part of the circuit, and shewed, by the usual phenomena, that the stream of electricity was rapidly passing. The wires in the muriatic acid were then slided within the third of an inch of each other. For the sake of brevity he avoids enumerating the effects which took place during several hours, and simply states, that the minus wire gave out some hydrogen during an hour; while the plus wire was corroded, and exhibited no oxyd; but a deposition of copper was formed round the minus, or lower wire, which began at its lower end: that no gas whatever appeared in this tube during two hours, though the deposition was going on, and the small tube shewed the continuance of the electric stream; and that the deposition, at the end of four hours, formed a ramified metallic vegetation, nine or ten times the bulk of the wire it surrounded.

In this experiment, it appeared that the influence of electricity increasing the oxydability of the upper wire, and affording nascent hydrogen from the lower, caused the

the latter to act as the precipitant of a solution of one and the same metal.

Mr Nicholson, we see, continues to call it electricity with the utmost confidence, as if it could not possibly be any thing else; and yet he says that the galvanic shock is much less forcible when passed through a number of persons than when passed only through one. This, we believe, does not hold in the shocks of common electricity; and the difference probably arises from the cuticle obstructing the passage of the one and not of the other. Volta himself says, that *this* electricity, for he too is desirous to prove it electricity, does not diffuse itself through the air. It is so universally known that very dry air is no conductor of electricity, that he must mean, on this occasion, air not uncommonly dry; otherwise the non diffusion of *this* electricity through air would not distinguish it, as he seems to admit it does, from common electricity. But what occasions this distinction, if the two electricities be the same?

Lieutenant-colonel Haldane, well known in the scientific world, made experiments with Volta's pillar, both in a horizontal and in a vertical position. With a large pillar, placed vertically, he obtained very weak signs of electricity. He connected the apparatus with the conductor of an electrical machine, and found the effect rather impeded than assisted by the common electric stream. He placed the plate of Bennet's electrometer in the circuit, without producing electric signs. He found that the galvanic apparatus, placed between the outside and inside of a jar, prevented its charging, and that it is also capable of conducting the charge, though not rapidly: and, on the whole, from the very minute exhibition of the attractive and repellent powers, while the causticity, the shock, and the oxydation, are so very powerful, he cannot be persuaded that electricity is the principal agent, though some might be generated, or disengaged, during the operation of the apparatus.

This is exactly our own opinion, which is strongly corroborated by the results of some very curious experiments made by Mr Cruickshank of Woolwich. These experiments our limits permit us not to detail. They were made with a view to ascertain the nature and relative proportions of the gases obtained from water and other fluids by this influence; and the author thinks himself authorised to conclude from them:

1. That hydrogen gas, mixed with a very small proportion of oxygen and ammonia, is somehow disengaged at the wire connected with the silver extremity of the machine; and that this effect is equally produced, whatever the nature of the metallic wire may be, provided the fluid operated upon be pure water.

2. That where metallic solutions are employed instead of water, the same wire which separates the hydrogen revives the metallic calx, and deposits it at the extremity of the wire in its pure metallic state; in this case no hydrogen gas is disengaged. The wire employed for this purpose may be of any metal.

3. That of the earthy solutions, those of magnesia and argil only are decomposed by the silver wire; a circumstance which strongly favours the production of ammonia.

4. That when the wire connected with the zinc extremity of the pile consists either of gold or platinum, a quantity of oxygen gas, mixed with a little azote and nitrous acid, is disengaged; and the quantity of gas thus obtained is a little better than $\frac{1}{3}$d of the hydrogen gas separated by the silver wire at the same time.

5. That when the wire connected with the zinc is silver, or any of the imperfect metals, a small portion of oxygenous gas is likewise given out; but the wire itself is either oxydated or dissolved, or partly oxydated and partly dissolved: indeed, the effect in this case produced upon the metal is very similar to that of the concentrated nitrous acid, where a great deal of the metal is oxydated, and but a small quantity held in solution.

6. That when the gases obtained by gold or platinum wires are collected together and exploded over mercury, the whole nearly disappears and forms water, with probably a little nitrous acid; for there was always a thick white vapour perceived for some time after the explosion. The residuary gas, in this case, appeared to be azote.

In reflecting on these experiments, it would appear that in some of them the water must be decomposed: but how this can be effected is by no means so easily explained. For example, it seems extremely mysterious how the oxygen should pass silently from the extremity of the silver wire to that of the zinc wire, and there make its appearance in the form of gas. It is to be observed, likewise, that this effect takes place which ever way the wires are placed, and whatever bends may be interposed between their extremities, provided the distance be not too great. On considering these facts more minutely, it appeared to Mr Cruickshank that the easiest and simplest mode of explanation would be, to suppose that the galvanic influence (whatever it may be) is capable of existing in two states, that is, in an oxygenated and deoxygenated state; that when it passes from metals to fluids containing oxygen, it seizes their oxygen, and becomes oxygenated; but when it passes from the fluid to the metal again, it assumes its former state, and becomes deoxygenated. Now when water is the fluid interposed, and the influence enters it from the silver side deoxygenated (and we suppose that it always passes from the deoxygenated to the oxygenated side), it seizes the oxygen of the water, and disengages the hydrogen, which accordingly appears in the form of gas; but when the influence enters the zinc wire, it parts with the oxygen, with which it had formerly united; and this either escapes in the form of gas, unites with the metal to form an oxyd, or, combined with a certain portion of water, &c. may, according to the German chemists, form nitrous acid. When a metallic solution is the interposed fluid, the effect produced may be explained in two ways; but the simplest is to suppose that the influence, in passing from the silver wire, seizes the oxygen of the metallic calx, and afterwards deposits it on entering the zinc one. In this case no gas should appear at the silver wire; but when a perfect metal is employed, oxygen should be disengaged from the zinc wire: and this, as has been already mentioned, is exactly what takes place.

What our author considers as the strongest argument in favour of this hypothesis, and what we consider as an argument equally strong to prove that galvanism differs essentially from electricity, is, that all fluids which do not contain oxygen, are incapable of transmitting the galvanic fluid, such as alcohol, æther, the fat

effential oils, as he has proved by direct experiment; but on the contrary, that all thofe which do contain oxygen conduct it more or lefs readily, as all aqueous fluids, metallic folutions, and acids, more efpecially the concentrated fulphuric acid; which it decompofes. In this laft inftance, the oxygen produced can hardly be afcribed to the decompofition of water; for this acid, when properly concentrated, does not contain any fenfible quantity. By this theory alfo we can readily explain the oxydation of the zinc plates in the machine; where the fluid in paffing from the different pairs of plates appears to be alternately oxygenated and deoxygenated. Although I am not (fays Mr Cruikfhank) by any means entirely fatisfied with this bypothefis, yet as it is the only one by which I can explain the different phenomena, it was thought advifable to throw it out, merely with a view to induce others to reafon upon the fubject, and to incite them to make experiments, by which alone truth can be afcertained.

We approve heartily of his conduct. It is for the fame reafon, and not to maintain at all hazards any preconceived opinion of our own, that we have urged every objection that occurs to us againft the hypothefis of the identity of galvanifm and electricity. Thefe fluids or influences appear to us to differ effentially; but ftill we admit that future experiments and future reafonings *may remove* our objections, which, however, ought never to be loft fight of *till* they be removed. If ingenious men, adopting implicitly the hypothefis of Volta and Mr Nicholfon, fhall inftitute a fet of experiments to afcertain the laws of the galvanic influence, they will be very apt to make their experiments fupport their hypothefis, inftead of employing them as guides to the temple of truth. Mr Nicholfon fays, that in all the experiments made by him and Mr Carlifle, the action of the inftrument was freely tranfmitted through the ufual conductors of electricity (meaning, we fuppofe, metals and watery fluids), but that it was ftopped by glafs and other non-conductors. We have experienced the fame thing, and fo far we acknowledge a ftriking refemblance between galvanifm and electricity; but, on the other hand, we have never been able to make any accumulation of galvanifm by means of coated electrics, whilft Mr Cruickfhank found that the galvanic influence cannot be tranfmitted through alcohol, ether, or effential oils. In thefe inftances, the difference between galvanifm and electricity feems to be as ftriking as the refemblance is in the others. Indeed thefe differences between the one and the other are fo many and fo great, that M. Fabbroni attributes the phenomena of galvanifm not to electricity, but to a chemical operation; to the tranfition of oxygen into a combination, and to the formation of a new compound. He had obferved, in repeating the common experiment, that if he wiped his tongue as accurately as poffible, the fenfation of tafte excited by the two metals was fo diminifhed as to be hardly diftinguifhed. The faliva, or fome other moifture, muft therefore be of fome importance in this phenomenon. He afterwards inftituted a fet of very proper experiments; from which it appeared to him that an evident chemical action takes place in the operations of galvanifm, and that it is unneceffary to feek farther for the nature of the new ftimulus. Galvanifm (he fays) is manifeftly a combuftion or oxydation of the metals; and the ftimulating principle may be either the caloric which is difengaged, or the oxygen which paffes into new combinations; or the new metallic falt; but which of thefe he has not afcertained.

Without adopting or rejecting thefe conclufions, we recommend them to the attention of our chemical readers; for it is only by expert and fcientific chemifts that we expect the nature and properties of galvanifm to be afcertained. In the mean time, it is proper to obferve, that the pile of Volta continues in order for about three days, and fcarcely three; and that on account of the corrofion of the fæces of the zinc, it is neceffary to renew them previous to each conftruction of the pile. This may be done by fcraping or grinding, or by cleaning them with diluted muriatic acid.

To avoid the trouble of conftantly repiling the pieces of filver and zinc, Mr Cruickfhank conftructed a kind of trough of baked wood, 26 inches in length, 1.7 inches deep, and 1.5 inches wide; in the fides of this trough grooves were made oppofite to each other, about the tenth of an inch in depth, and fufficiently wide to admit one of the plates of zinc and filver when foldered together; three of thefe grooves were made in the fpace of one inch and three tenths, fo that the whole machine contained 60 pair of plates. A plate of zinc and filver, each 1.6 inches fquare, well cemented together, were introduced into each of thefe grooves or notches, and afterwards cemented into the trough by a compofition of rofin and wax, fo perfectly that no water could pafs from one cell to the other, nor between the plates of zinc and filver. This circumftance muft be ftrictly attended to, elfe the machine will be extremely imperfect. When all the plates were thus fecured in the trough, the interftices or cells formed by the different pairs of plates were filled with a folution of the muriat of ammonia, which here fupplied the place of the moiftened papers in the pile, but anfwered the purpofe much better. It is hardly neceffary to obferve, that in fixing the zinc and filver plates, they muft be placed regularly, as in the pile, *viz.* alternately zinc and filver, the filver plate being always on the fame fide. When a communication was made between the firft and laft cell, a ftrong fhock was felt in the arms, but fomewhat different from that given by the pile, being quicker, lefs tremulous, and bearing a greater refemblance to the common electrical fhock. He conftructed two of thefe machines, which contained in all 100 pair of plates; thefe when joined together gave a very ftrong fhock, and the fpark could be taken in the day-time at pleafure; but what furprifed him not a little, was the very flender power which they poffeffed in decompofing water: in this refpect they were certainly inferior to a pile of 30 pair, although fuch a pile would not give a fhock of one third the ftrength.

This apparatus retained its power for many days, and would in all probability have retained it much longer, had not the fluid got between the dry furfaces of the metals. To remedy this defect, he foldered the zinc and filver plates together, and found that this method anfwers very well. The zinc plates may be cleaned at any time, by filling the different cells for a few minutes with the dilute muriatic acid. Although this apparatus may not entirely fuperfede the pile, efpecially if it fhould be found to decompofe water, &c. but flowly, yet in other refpects it will no doubt be found very convenient and portable.

If this article be thought long, and if we appear to have loft fight of our original fubject, the *Torpedo*, we

have only to plead in excuse for our conduct, that whilst we could not avoid pointing out the resemblance between the shock given by the torpedo and that by Volta's apparatus, we felt it a kind of duty to embrace the only opportunity that we shall have of laying before our readers the additional information respecting the phenomena of GALVANISM which we have received since the publication of that article. These phenomena are yet new, and they are unquestionably important; indeed so very important, that to us it appears neither impossible, nor even improbable, that to the galvanic agency of metals and minerals may be attributed volcanoes and earthquakes.

TOUCAN, or AMERICAN GOOSE, is one of the modern constellations of the southern hemisphere, consisting of nine small stars.

TRACTORS, METALLIC. See PERKINISM in this *Suppl.*

TRACTRIX, in geometry, a curve line, called also CATENARIA; which see, *Encycl.* and ARCH, *Suppl.*

TRADESCANT (John), an ingenious naturalist and antiquary, was, according to Anthony Wood, a Fleming or a Dutchman. We are informed by Parkinson, that he had travelled into most parts of Europe, and into Barbary; and from some emblems remaining upon his monument in Lambeth church-yard, it plainly appears that he had visited Greece, Egypt, and other eastern countries. In his travels, he is supposed to have collected, not only plants and seeds, but most of those curiosities of every sort which, after his death, were sold by his son to the famous Elias Ashmole, and deposited in his museum at Oxford. When he first settled in this kingdom cannot, at this distance of time, be ascertained. Perhaps it was at the latter end of the reign of Queen Elizabeth, or the beginning of that of King James I. His print, engraven by Hollar before the year 1656, which represents him as a person very far advanced in years, seems to countenance this opinion. He lived in a great house at South Lambeth, where his museum was frequently visited by persons of rank, who became benefactors thereto: among these were King Charles I. (to whom he was gardener), Henrietta Maria his Queen, Archbishop Laud, George Duke of Buckingham, Robert and William Cecil, Earls of Salisbury, and many other persons of distinction. John Tradescant may therefore be justly considered as the earliest collector (in this kingdom) of every thing that was curious in natural history, viz. minerals, birds, fishes, insects, &c. He had also a good collection of coins and medals of all sorts, besides a great variety of uncommon rarities. A catalogue of these, published by his son, contains an enumeration of the many plants, shrubs, trees, &c. growing in his garden, which was pretty extensive. Some of these plants are, if not totally extinct, at least become very uncommon, even at this time: though this able man, by his great industry, made it manifest, in the very infancy of botany, that there is scarce any plant extant in the known world that will not, with proper care, thrive in this kingdom.

When his house at South Lambeth, then called *Tradescant's Ark*, came into Ashmole's possession, he added a noble room to it, and adorned the chimney with his arms, impaling those of Sir William Dugdale, whose daughter was his third wife; where they remain to this day.

It were much to be wished, that the lovers of botany had visited this once famous garden before, or at least in the beginning of the present century. But this seems to have been totally neglected till the year 1749, when Dr Watson and the late Dr Mitchell favoured the Royal Society with the only account now extant of the remains of Tradescant's garden.

When the death of John Tradescant happened is not known; no mention being made thereof in the register-book of Lambeth church.

TRAJECTORY, a term often used, generally for the path of any body, moving either in a void, or in a medium that resists its motion; or even for any curve passing through a given number of points. Thus Newton, Princip. lib. 1. prop. 22. proposes to describe a trajectory that shall pass through five given points.

TRAITOR's ISLAND, one of the Archipelago called NAVIGATOR's *Islands*, in the South Sea (See that article, *Suppl.*). It is low and flat, with only a hill of some height in the middle; and is divided into two parts by a channel, of which the mouth is about 1[illegible] toises wide. It abounds with bannanas, yams, and the finest cocoa-nuts, which Perouse says he ever saw. About twenty canoes approached the French ships without dread, traded with a good deal of honesty, and never refused, like the natives of the archipelago of Navigators, to give their fruit before they were paid for it; nor, like them, did they give a preference to beads over nails and pieces of iron. They spoke, however, the same language, and had the same ferocious look, their dress, their manner of tatowing, and the form of their canoes, were the same; nor could we (says the author) doubt that they were one and the same people: they differed, indeed, in having universally two joints cut off from the little finger of the left hand; whereas, in the islands of Navigators, I only perceived two individuals who had suffered that operation. They were also of much lower stature, and far less gigantic make; a difference proceeding, no doubt, from the soil of these islands, which being less fertile, is consequently less favourable to the expansion of the human frame.

TRAMMELS, in mechanics, an instrument used by artificers for drawing ovals upon boards, &c. One part of it consists of a cross with two grooves at right angles; the other is a beam carrying two pins, which slide in those grooves, and also the describing pencil. All the engines for turning ovals are constructed on the same principles with the trammels: the only difference is, that in the trammels the board is at rest, and the pencil moves upon it; in the turning engine, the tool, which supplies the place of the pencil, is at rest, and the board moves against it. See a demonstration of the chief properties of these instruments by Mr Ludlam, in the *Phil. Transf.* vol lxx. p. 378, &c.

TRANSFORMATION, in geometry, is the changing or reducing of a figure, or of a body, into another of the same area, or the same solidity, but of a different form. As, to transform or reduce a triangle to a square, or a pyramid to a parallelopipedon.

TRANSFORMATION of Equations, in algebra, is the changing equations into others of a different form, but of equal value. This operation is often necessary, to prepare equations for a more easy solution.

TRANSLATION, in literature, is a matter of so much importance, that no other apology can be made for

for the very imperfect manner in which it is treated in the *Encyclopædia*, than a candid declaration that it was impossible to enter at all upon the subject within the narrow limits to which we were then restricted by the proprietors of the work. The fundamental laws of translation, which we gave from Dr Campbell of Aberdeen, we believe indeed to be unexceptionable; but the question is, how are these laws to be obeyed?

In order that a translator may be enabled to give a complete transcript of the ideas of the original work, it is almost needless to observe, that he must possess a perfect knowledge of both languages, *viz*. that of his author, and that into which he is to translate; and that he must have a competent acquaintance with the subject of which his author treats. These propositions we consider as self evident; but if any of our readers shall be of a different opinion, we refer them to an *Essay on the Principles of Translation*, published 1797 by Cadell and Davies, London, where they will find our doctrine very clearly illustrated. It may be proper to add, that such a knowledge of the Greek and Latin languages as merely enables a man to read them with ease and entertainment to himself, is by no means sufficient to qualify him for translating every Greek and Latin book, even though it treats of a subject with which he has a general acquaintance. The religious rites and ceremonies of the Greeks and Romans, as well as the radical words of their language, were derived from the East; and he who is an absolute stranger to oriental literature, will be very liable to mistake occasionally the sense of Greek and Roman authors who treat of religious subjects. We could illustrate the truth of this position by quotations from some of the most admired modern translations of the Greek Scriptures, which we have no hesitation to say fall very short of the authorised version in accuracy as well as in elegance. The divines employed by King James to translate the Old and New Testaments were profoundly skilled in the learning, as well as in the languages, of the East; whilst some of those who have presumed to improve their version seem not to have possessed a critical knowledge of the Greek tongue, to have known still less of the Hebrew, and to have been absolute strangers to the dialect spoken in Judea in the days of our Saviour, as well as to the manners, customs, and peculiar opinions of the Jews sects. Neither metaphysical acuteness, nor the most perfect knowledge of the principles of translation in general, will enable a man who is ignorant of these things to improve the authorised version either of the Gospels or the Epistles; for such a man knows not accurately, and therefore cannot give a complete transcript of the ideas of the original work.

But supposing the translator completely qualified with respect to knowledge, it becomes a question, whether he may, in any case, add to or retrench the ideas of his author? We are strongly inclined to think, that, in no case, it is allowable to take such liberties; but the ingenious and elegant essayist, whose work on the principles of translation we must always quote with respect, is of a different opinion. "To give a general answer (says he) to this question, I would say, that this liberty may be used, but with the greatest caution. It must be further observed, that the superadded idea shall have the most necessary connection with the original thought, and actually increase its force. And, on the other hand, that whenever an idea is cut off by the translator, it must be only such as is an accessory, and not a principle, in the clause or sentence. It must likewise be confessedly redundant, so that its retrenchment shall not impair or weaken the original thought. Under these limitations, a translator may exercise his judgment, and assume to himself, in so far, the character of an original writer."

Of the judicious use, as he thinks it, of this liberty, the author quotes many examples, of which we shall select three, as well calculated to illustrate our own ideas of the subject.

In the first book of the Iliad, Achilles, having resolved, though indignantly, to give up Briseis, desires Petroclus to deliver her to the heralds of Agamemnon;

> Ὡς φατο· Πατροκλος δε φιλῳ επεπειθεθ' εταιρῳ·
> Εκ δ' αγαγε κλισιης Βρισηιδα καλλιπαρηον,
> Δωκε δ' αγειν· τω δ' αυτις ιτην παρα νηας Αχαιων·
> Ἡ δ' αεκουσ' ἁμα τοισι γυνη κιεν· *Iliad*, A. 345.

> Patroclus now th' unwilling beauty brought;
> She in soft sorrows, and in pensive thought,
> Past silent, as the heralds held her hand,
> And oft look'd back, slow moving o'er the strand.
> POPE.

Our author thinks, and we heartily agree with him, that the amplification in the three last lines of this version highly improves the effect of the picture; but we cannot consider this amplification as a new idea superadded. It was the object of Homer to inform his countrymen, that Briseis went with the heralds *unwillingly*. This he does by the words ἡ δ' αεκουσ' ἁμα τοισι γυνη κιεν and it is by no means improbable, that the rhythmical movement of the verse may have presented to the ancient Greeks the image of the lady walking slowly and reluctantly along. This image, we are sure, is not produced by a literal translation of the Greek words into English; and therefore it was Pope's duty, not to add to the ideas of the original, but, by amplification, to present to his own countrymen the picture which Homer, by the superiority of the Greek language and rhythm, had presented to his.

In the ninth book of the Iliad, where Phœnix reminds Achilles of the care he had taken of him while an infant, one circumstance, extremely mean, and even disgusting, is found in the original:

> —— ὁτε δη σ' επ' εμοισιν εγω γουνασσι καθισσας
> Οψου τ' ασαιμι προταμων, και οινον επισχων·
> Πολλακι μοι κατεδευσας επι στηθεσσι χιτωνα,
> Οινου αποβλυζων εν νηπιεη αλεγεινη.

The literal version of these lines is indeed very gross: "When I placed you before my knees, I crammed you with meat, and gave you wine, which you often vomited upon my bosom, and stained my clothes, in your troublesome infancy:" but we cannot agree with our author, that the English reader is obliged to Pope for having altogether sunk this nauseous image. What is, or ought to be, our object in reading Homer? If it be merely to delight our ear with sonorous lines, and please our fancy with grand or splendid images, the translator certainly did right in keeping out of view this disgusting picture of savage life; but when he did so, he cannot be said to have given a complete transcript of his author's ideas. To please ourselves, however, with splendid images, is not our only object when studying the

the works of the ancient poets. Another, and in our opinion a more important object, is to acquire a lively notion of ancient manners; and if so, Pope grossly misleads the mere English reader, when, instead of the beastly image of Homer, he presents him with the following scene, which he may daily meet with in his own family, or in the families of his friends:

> Thy infant breast a like affection show'd,
> Still in my arms, an ever pleasing load;
> Or at my knee, by Phœnix would'st thou stand,
> No food was grateful but from Phœnix hand:
> I pass my watchings o'er thy helpless years,
> The tender labours, the compliant cares.

This is a picture of the domestic manners of Great Britain in the 18th century, and not of Greece in the heroic ages

In the beginning of the eighth book of the Iliad, Homer puts into the mouth of Jove a very strange speech, stuffed with braggart vaunting and ludicrous images. This, as our author observes, is far beneath the dignity of the thunderer; but it is only beneath the dignity of the thunderer as our habits and modes of thinking compel *us* to conceive such a being. The thunderer of the Greeks was a notorious adulterer and sodomite, whose moral character sinks beneath that of the meanest of our bravos; and as he had dethroned his father, and waged for some time a doubtful war with certain *earthly* giants, it does not appear to us that the boasting speech which Homer puts into his mouth is at all unsuitable to his acknowledged attributes. But whether it be or not, was not the translator's concern. Homer, when he composed it, certainly thought it not unworthy of the thunderer; and whatever Pope's opinion might be, he had no right to substitute his own notions of propriety for those of his author. The mythological tales of the poets, and more especially of Homer and Hesiod, constituted, as every one knows, the religious creed of the vulgar Greeks (see POLYTHEISM, n° 33. *Encycl.*); and this circumstance makes it doubly the duty of a translator to give, on such subjects, a fair transcript of his author's ideas, that the mere English reader, for whom he writes, may know what the ancients really thought of the objects of their idolatrous worship. This Pope has not done in the speech under consideration; and has therefore, in our opinion, deviated widely from the first and most important of the three general laws of translation. Johnson has apologized, we think sufficiently, for many of Pope's embellishments of his author; but he has not attempted to make an apology for such embellishments as alter the sense. We cannot indeed conceive a pretence upon which it can ever be allowable in a translator to add to the ideas of his author, to retrench, or to vary them. If he be translating history, and find his author advancing what he *believes* to be false, he may correct him in a note; but he has no right to make one man utter, as his own, the belief or the sentiments of another, when that belief, and those sentiments, are *not* his own. If he be translating a work of science, he may likewise correct the errors of his author in notes, as Dr Clerke corrected those of Rohault; but no man has a right to give to a Rohault the science of a Newton The translator of a poem may certainly employ amplification to place in a striking light the images or the sentiments of the original work; but he must not alter those images or sentiments so as to make that appear grand or elegant in the version, which is mean or disgusting in the original. On every occasion on which he takes such liberties as these, he ceases to be a translator, and becomes a faithless paraphrast.

The second general law of translation, though certainly less important, is perhaps more difficult to be observed than the first. We have stated it in these words: (See TRANSLATION. *Encycl.*) "The style and manner of the original should be preserved in the translation;" but it is obvious, that this cannot be done by him who possesses not sufficient taste and judgment to ascertain with precision to what class the style of the original belongs. "If a translator fail in this discernment, and want this capacity, let him be ever so thoroughly master of the sense of his author, he will present him through a distorting medium, or exhibit him in a garb that is unsuitable to his character." It would obviously be very improper to translate the elegantly simple language of Cæsar into rounded periods like those of *The Rambler*, or the Orations of Cicero into the language of Swift.

The chief characteristic of the historical style of the sacred Scriptures is its simplicity; and that simplicity is, for the most part, well preserved in the authorised version. It is, however, lost in many of the modern versions. Castalio's, for instance, though intitled to the praise of elegant latinity, and though, in general, faithful to the sense of the original, yet exhibits numberless transgressions of the law which is now under consideration. Its sentences are formed in long and intricate periods, in which many separate members are artfully combined: and we observe a constant endeavour at classical phraseology and ornamented diction, instead of the beautiful simplicity of the original.

The version of the Scriptures by Arias Montanus is, in some respects, a contrast to that of Castalio. By adopting the literal mode of translation, Arias undoubtedly intended to give as faithful a picture as he could, both of the sense and of the manner of the original. Not attending to the peculiar idioms of the Hebrew, Greek, and Latin tongues, which, in some respects, are very different from each other, he has, by giving to his Latin the combination and idioms of the two first of these languages, sometimes made the sacred writers talk absurdly. In Latin, as every school boy knows, two negatives make an affirmative, whilst in Greek they add force to the negation. Χωρις εμου ου δυνασθε ποιειν ουδεν signifies, "Without me ye can do nothing," or, "Ye cannot *possibly* do any thing;" but Arias has translated the words *sine me non potestis facere nihil*, *i. e.* "without me ye cannot do nothing," or, "ye *must* do something," which is directly contrary to the meaning of our Lord. It is not therefore by translating literally or verbally that we can hope to preserve the style and manner of the original

To express in florid or elevated language the ideas of an author who writes himself in a simple style, is not to give in the version a just picture of the original; but to attempt, for the sake of verbal accuracy, to introduce into one language the peculiar idioms or construction of another, is still worse, as in this mode of translation the sense, as well as the manner of the original, is lost. The rule obviously is to use, in the version, the words

Translation

words and phraseology which we have reason to believe that the author would himself have used, had he been master of the language into which we are translating his ideas. Thus, if we are to translate into English a piece of elegantly simple Greek or Latin, we must make ourselves completely master of the author's meaning, and, neglecting the Greek or Latin *idioms*, express that meaning in elegantly simple English. We need not add, that when the language of the original is florid or grand, if that style be suited to the subject, the language of the translation should be florid or grand likewise; but care must always be taken that perspicuity be not sacrificed to ambitious ornaments of any kind; for ornaments which obscure the sense are worse than useless.

If these reflections be just, it is obvious that a poem cannot be properly translated into prose. The mere sense may doubtless be thus transferred from one language into another, as has generally been done by Macpherson in his hobbling version of the Iliad, and perhaps more completely by a late translator of Anacreon; but in such a version, the style and manner of the original must necessarily be lost. Of this the following accurate prose translation of Anacreon's ninth ode (on a dove) is a striking instance:

"O lovely Pigeon! whence, whence do you fly? Whence, speeding through the air, do you breathe, and distil so many perfumes? Who is your master? For it concerns me to know. 'Anacreon sent me to a youth, —to Bathyllus, at present the prince, and disposing of all things Venus sold me, receiving a little hymn in return. And I serve Anacreon in such transactions as these: and now I carry his letters, such as you see: and he affirms, that he will immediately make me free. But I will remain a servant with him although he may dismiss me: For wherefore does it behove me to fly, both over mountains, and fields, and to perch on trees, devouring some rustic food? Now indeed I eat bread, snatching it from the hands of Anacreon himself; and he gives to me the wine to drink which he drinks before me; and having drunk, I perhaps may dance, and cover my master with my wings: then going to rest, I sleep upon the lute itself. You have it all;—begone: you have made me more talkative, O mortal! than even a jay *."

* *The Odes of Anacreon, translated into English prose, printed at York, 1796.*

How inferior is the general effect of this piece of prose to that of the well-known poetical versions of Addison and Johnson? and yet the mere *ideas* of the original are perhaps more faithfully transcribed by this anonymous writer than by either of those elegant translators. The emotions indeed excited by the original are not here brought into view.

The third general law of translation is so nearly allied to the second, that we have very few directions to give for the observation of it. He who, in his version, preserves the style and manner of the original, as we have endeavoured to shew that they *ought* to be preserved, will, of course, give to the translation the ease of original composition. The principal difficulty that he has to encounter in this part of his task, will occur in the translating of idiomatical and proverbial phrases. Hardly any two languages are constructed precisely in the same way; and when the structure of the English language is compared with that of the Greek and Latin, a remarkable difference between the ancient and modern tongues is found to pervade the whole. This must occasion very considerable difficulty; but it is a difficulty which will be removed by a due observance of the former law, which directs the translator to make his author speak English in such a style to Englishmen as he spoke his own tongue to his own countrymen, and of course to use the English idiom with English words. But what is to be done with those proverbial phrases of which every language has a large collection, and which allude to local customs and manners?

The ingenious author of the Essay so often quoted, very properly observes, in answer to this question, that the translation is perfect when the translator employs, in his own language, an idiomatic phrase corresponding to that of the original. "It is not (says he) possible perhaps to produce a happier instance of translation by corresponding idioms, than Sterne has given * in the translation of Slawkenbergius's tale. *Nihil me penitet hujus nasi*, quoth Pamphagus; that is, "My nose has been the making of me." *Nec est cur pæniteat*; that is, "How the deuce should such a nose fail?" *Miles peregrini in faciem suspexit!* "The centinel looked into the stranger's face. Never saw such a nose in his life!"

* *Tristra. Shandy.*

"As there is nothing (continues our author) which so much conduces both to the ease and spirit of composition as a happy use of idiomatic phrases, there is nothing which a translator, who has a moderate command of his own language, is so apt to carry to an extreme." Of this he gives many striking examples from Echard's translations of Terence and Plautus, for which we must refer the reader to the Essay itself. He observes, likewise, that in the use of idiomatic phrases, a translator frequently forgets both the country of his original author, and the age in which he wrote; and while he makes a Greek or Roman speak French or English, he unwittingly puts into his mouth allusions to the manners of modern France or England. This, to use a phrase borrowed from painting, may be termed an offence against the *costume*. The proverbial expression βατραχῳ ὕδωρ, in Theocritus, is of similar import with the English proverb, *to carry coals to Newcastle*; and the Scotch, *to drive salt to Dysart*; but it would be a gross impropriety to use either of these expressions in the translation of an ancient classic. Of such improprieties our author points out many instances both in French and English translations of the classics; and he might have increased the number by quotations from Blackwell's Memoirs of the Court of Augustus, where, instead of Roman senators and their wives, we meet with modern gentlemen and ladies, with *secretaries at war*, *paymasters*, *commissary generals*, and *lord high admirals*. It is true the memoirs of the court of Augustus is no translation; but with respect to costume, it is necessarily subject to the laws of translation.

Offences against costume are often committed by the use of improper words as well as of improper phrases. To introduce into dignified and solemn composition words associated with mean and ludicrous subjects, is equally a fault in an original author and in a translator; and it is obviously improper, in the translation of works of very high antiquity, to make use of words which have but lately been admitted into the language of the translator. Faults of this kind are very frequent in Dr Geddes's translation of the Bible, as when the *passover* is called the *skipover*; the tabernacle of the congrega-

tion, the *convention-tent*; and a burnt-offering, a *holocaust*. The first of these expressions presents to the imagination an image profanely ludicrous: the second, brings into our view the French Convention, which, we suspect, occupied no small portion of the Doctor's thoughts, when they should have been wholly employed on the sacred text; and the word *holocaust*, which must be unintelligible to the mere English reader, is, in the mind of every man of letters, closely associated with the abominable rites performed at the sacrifices of the ancient heathens. But it is needless to point out faults of this kind in a work which is open to more serious objections, and which, we trust, shall never be generally read. We are sorry that truth compels us to say, that the novel expressions introduced by Dr Campbell into his version of the gospels—such as *confluence* for multitude, and *reign* for kingdom—are, to say the best of them, no improvements of the authorised version. We will not rank them with Dr Geddes's innovations, because we will not class the great author of the *Dissertation on Miracles* with a paradoxical Christian of no communion; but we do not think that Dr Campbell's laurels were freshened on his brow by the translation of the Gospels.

We shall conclude this article with the following reflections, taken from the Essay which has been so often quoted:

"If the order in which we have classed the three general laws of translation be their just and natural arrangement, which, we presume, will hardly be denied, it follows, that, in every case where it is necessary to make a sacrifice of one of these laws to another, a due regard ought to be paid to their rank and comparative importance. When the genius of the original language differs much from that of the translation, it is often necessary to depart from the author's manner in order to convey a faithful picture of his sense; but it would be highly preposterous to depart, in any case, from the sense, for the sake of imitating the manner. Equally improper would it be, to sacrifice either the sense or manner of the original, if these can be preserved consistently with purity of expression, to a fancied ease or superior gracefulness of composition; and it is certain that the sense may always be preserved, though to purity of expression the manner of the original must sometimes be sacrificed."

TRAPEZOID, sometimes denotes a trapezium that has two of its sides parallel to each other; and sometimes an irregular solid figure, having four sides not parallel to each other.

TRAVERSE, in gunnery, is the turning a piece of ordnance about, as upon a centre, to make it point in any particular direction.

Traverse, in fortification, denotes a trench with a little parapet, sometimes two, one on each side, to serve as a cover from the enemy that might come in flank.

Traverse, in a wet foss, is a sort of gallery, made by throwing saucissons, joists, fascines, stones, earth, &c. into the foss, opposite the place where the miner is to be put, in order to fill up the ditch, and make a passage over it.

Traverse also denotes a wall of earth, or stone, raised across a work, to stop the shot from rolling along it.

Traverse also sometimes signifies any retrenchment, or line fortified with fascines, barrels, or bags of earth, or gabions.

TRAVESTY, or burlesque translation, is a species of writing which, as it partakes, in a great degree of original composition, is not to be measured by the laws of serious translation. It conveys neither a just picture of the sentiments, nor a faithful representation of the style and manner of the original; but pleases itself in exhibiting a ludicrous caricatura of both. It displays an overcharged and grotesque resemblance, and excites our risible emotions by the incongruous association of dignity and meanness, wisdom and absurdity. This association forms equally the basis of travesty and of ludicrous parody, from which it is no otherwise distinguished than by its assuming a different language from the original. In order that the mimickry may be understood, it is necessary that the writer choose, for the exercise of his talents, a work that is well known, and of great reputation. Whether that reputation is deserved or unjust, the work may be equally the subject of burlesque imitation. If it has been the subject of general, but undeserved praise, a parody or a travesty is then a fair satire on the false taste of the original author and his admirers, and we are pleased to see both become the objects of a just castigation. The *Rehearsal*, *Tom Thumb*, and *Chrononhotonthologos*, which exhibit ludicrous parodies of passages from the favourite dramatic writers of the times, convey a great deal of just and useful criticism. If the original is a work of real excellence, the travesty or parody detracts nothing from its merit, nor robs the author of the smallest portion of his just praise. We laugh at the association of dignity and meanness; but the former remains the exclusive property of the original, the latter belongs solely to the copy. We give due praise to the mimical powers of the imitator, and are delighted to see how ingeniously he can elicit subjects of mirth and ridicule from what is grave, dignified, pathetic, or sublime.

But this species of composition pleases only in a short specimen. We cannot bear a lengthened work in travesty. The incongruous association of dignity and meanness excites risibility chiefly from its being unexpected. Cotton's and Scarron's Virgil entertain but for a few pages: the composition soon becomes tedious, and at length disgusting. We laugh at a short exhibition of buffoonery; but we cannot endure a man who, with good talents, is constantly playing the fool.

TREACLE (see *Encycl.*) or Melasses, is a substance very wholesome, but of a taste disagreeably sweet. Methods have accordingly been proposed for purifying it, so as that it may, on many occasions, supply the place of refined sugar, which has long been at a price which a great number of poor persons cannot afford to pay for what must now be considered as a necessary of life. The following is the process for purifying treacle, given by the M. Cadet (Devaux) in the *Feuille du Cultivateur*, founded upon experiments made by Mr Lowitz of Petersburgh:

Take of treacle 24 lbs. of water 24 lbs. of charcoal, thoroughly burnt, 6 lbs. Bruise the charcoal grossly, mix the three substances in a caldron, and let the mixture boil gently upon a clear wood-fire. After it has boiled for half an hour, pour the liquor through a straining-bag, and then replace it upon the fire, that the superfluous water may be evaporated, and that the treacle may be brought to its original consistence. There is little or no loss by this operation, as 24 lbs. of treacle give nearly the same quantity of syrup.

This process has been repeated in the large way, and has succeeded: the treacle is sensibly ameliorated, so

Trebiſond. ‖ Triangle.

that it may be uſed for many diſhes; nevertheleſs, those with milk, and the ſine or aromatic *liqueurs*, are not near ſo good as with ſugar.

TREBISOND, a large, populous, and ſtrong town of Turkey in Aſia, in the province of Jenich, with a Greek archbiſhop's ſee, a harbour, and a caſtle. It is ſeated at the foot of a very ſteep hill. The walls are ſquare and high, with battlements; and are built with the ruins of ancient ſtructures, on which are inſcriptions not legible. The town is not populous; for there are more woods and gardens in it than houſes, and theſe but one ſtory high. The caſtle is ſeated on a flat rock, with ditches cut therein. The harbour is at the eaſt end of the town, and the mole built by the Geneoſe is almoſt deſtroyed. It ſtands on the Black Sea, 104 miles north-weſt of Erzerum, and 440 eaſt of Conſtantinople. E. Long. 4[illegible] 25. N. lat. 40° 45.

TREE. Under this title (*Encycl.*) we gave an account of the method recommended by Meſſrs Forſyth and Hitt for curing injuries and defects in trees. The actual cautery is employed in Cevennes, and in the department de l'Allier, in France, for ſtopping the progreſs of rottenneſs in large trees. When they perceive that this very common and deſtructive diſeaſe begins to make ſome progreſs in the cheſnut-tree, by excavating its trunk, they collect heath, and other combuſtible vegetables, and burn them in the very cavity, till the ſurface is completely converted into a coal. It ſeldom happens that the tree periſhes by the effect of this operation, and it is always found that this remedy ſuſpends the progreſs of the decay. It is practiſed in the ſame manner, and with ſimilar ſucceſs, on the white oak. When we compare the effects of the actual cautery on the animal ſyſtem, in ſimilar diſeaſes, a new reſemblance is ſeen between the diſeaſes which affect the organic beings of both kingdoms, as well as between the remedies by which they may be oppoſed.—*Nicholſon's Journal.*

TRIANGLE, Arithmetical, a kind of numeral triangle, or triangle of numbers, being a table of certain numbers diſpoſed in form of a triangle. It was ſo called by Paſcal; but he was not the inventor of this table, as ſome writers have imagined, its properties having been treated of by other authors ſome centuries before him, as is ſhewn in Dr Hutton's Mathematical Tracts, vol. i. p. 69. &c.

The form of the triangle is as follows:

1					
1	1				
1	2	1			
1	3	3	1		
1	4	6	4	1	
1	5	10	10	5	1
1	6	15	20	&c.	
1	7	21	&c.		
1	8	&c.			
1	9				
1					

And it is conſtructed by adding always the laſt two numbers of the next two preceding columns together, to give the next ſucceeding column of numbers.

The firſt vertical column conſiſts of units; the ſecond, a ſeries of the natural numbers 1, 2, 3, 4, 5, &c.; the third, a ſeries of triangular numbers 1, 3, 6, 1[illegible], &c.; the fourth, a ſeries of pyramidal numbers, &c. The oblique diagonal rows, deſcending from left to right, are alſo the ſame as the vertical columns. And the numbers taken on the horizontal lines are the coefficients of the different powers of a binomial. Many other properties and uſes of theſe numbers have been delivered by various authors, as may be ſeen in the Introduction to Hutton's Mathematical Tables, pages 7, 8, 75, 76, 77, 89, ſecond edition.

Triangular ‖ Trinitarians.

TRIANGULAR Compasses, are ſuch as have three legs or feet, by which any triangle, or three points, may be taken off at once. Theſe are very uſeful in the conſtruction of maps, globes, &c.

Triangular Numbers, are a kind of polygonal numbers; being the ſums of arithmetical progreſſions, which have 1 for the common difference of their terms.

Thus, from theſe arithmeticals 1 2 3 4 5 6,
are formed the triangular numbers 1 3 6 10 15 21,
or the third column of the arithmetical triangle abovementioned.

The ſum of any number n of the terms of the triangular numbers, 1, 3, 6, 10, &c. is =

$$\frac{n^3}{6}+\frac{n^2}{2}+\frac{n}{3}, \text{ or } \frac{n}{1}\times\frac{n+1}{2}\times\frac{n+2}{3}$$

which is alſo equal to the number of ſhot in a triangular pile of balls, the number of rows, or the number in each ſide of the baſe, being n.

The ſum of the reciprocals of the triangular ſeries, infinitely continued, is equal to 2; viz.

$$1+\tfrac{1}{3}+\tfrac{1}{6}+\tfrac{1}{10}+\tfrac{1}{15}, \&c. = 2.$$

For the rationale and management of theſe numbers, ſee *Malcolm's Arith.* book 5. ch. 2.; and *Simpſon's Algeb.* ſec. 15.

TRIESTE, a ſmall, but ſtrong and ancient ſeaport of Italy, in Iſtria, on the gulph of Venice, with a biſhop's ſee. It is beautifully ſituated on the ſide of a hill, about which the vineyards form a ſemicircle. The ſtreets are narrow; but there is a large ſquare, where they keep the annual fair. The harbour is ſpacious, but not good; becauſe it is open to the W. and S. W. winds. The inhabitants have a good trade in ſalt, oil, almonds, iron, &c. brought from Laubach; and they make good wines. The cathedral, and the late Jeſuits church, are the two beſt buildings. It belongs to the Houſe of Auſtria, and is eight miles north of Capo d'Iſtria, and 8[illegible] north-eaſt of Venice. E. Long. 14. 4. N. Lat. 45. 56.

TRINITARIANS (Order of), was inſtituted at Rome in the year 1198, under the pontificate of Innocent III. the founders whereof were John de Matha and Felix de Valois. His Holineſs gave them permiſſion to eſtabliſh this order for the deliverance of captives, who groaned under the tyranny of the infidels: he gave them as a habit a white gown, ornamented with a red and blue croſs. After the death of the two founders, Pope Honorious III. continued the order; and their rule was approved by his ſucceſſor Clement IV. in 1267. At firſt they were not permitted to eat fleſh; and when they travelled, were to ride only upon aſſes. But their rule was corrected and mitigated by the biſhop of Paris, and the abbots of St Victor and St Genevieve, who allowed them to eat any kind of food, and to uſe horſes. This order poſſeſſed, at one time, about 250 convents in 13 different provinces: ſix of which were in France; namely, France, Normandy, Picardy, Champaine, Languedoc, and Provence; three in Spain, viz. New Caſtile, Old Caſtile, and Arragon; one in Italy, and one in Portugal. There was formerly the province of England, where this order had 43 houſes; that of Scotland, where it had nine; and that

that of Ireland, where it had 52; beſides a great number of monaſteries in Saxony, Hungary, Bohemia, and other countries. The convent of Cerfroy in France was head of the order. It is impoſſible for us to ſay what is now the ſtate of the order, which can have no viſible exiſtence in France, and is probably ſuppreſſed even in Italy.

TRIONES, in aſtronomy, a ſort of conſtellation, or aſſemblage of ſeven ſtars in the Urſa Major, popularly called *Charles's Wain*.—From the *ſeptem triones* the north pole takes the denomination *ſeptentrio*.

TRIPOLI OF SYRIA is, according to Mr Browne, by no means ſo populous a place as we were led to repreſent it in the *Encyclopædia*. It is indeed, he ſays, a city of ſome extent, ſituated about a mile and a half from the ſea; but inſtead of ſixty, he eſtimates its population at about ſixteen thouſand. The air is rendered unwholeſome by much ſtagnant water. The town is placed on a ſlight elevation, the length conſiderably exceeding the breadth. On the higheſt ground, to the ſouth, is the caſtle, formerly poſſeſſed by the earls of Tripoli; it is large and ſtrong. Hence is viſible a part of mount Libanus, the ſummit of which is covered with ſnow. The gardens in the vicinity are rich in mulberry and other fruit trees. The city is well built, and moſt of the ſtreets are paved.

Here is found a number of Mohammedan merchants, ſome of the richeſt and moſt reſpectable in the empire. Silk is the chief article of commerce.

The *miri*, or fixed public revenue paid by Tripoli to Conſtantinople, is only about L. 1000 Sterling, 20 purſes, a-year. Syria at preſent contains only four Paſhaliks, Damaſcus, Aleppo, Acrê, and Tripoli; the laſt of which is the ſmalleſt in territory and power. Our author obſerved no antiquities at Tripoli; but the country round it is noted for producing the beſt tobacco in Syria.

TRISECTION, the dividing a thing into three equal parts. The term is chiefly uſed in geometry, for the diviſion of an angle into three equal parts. The *triſection of an angle* geometrically, is one of thoſe great problems, whoſe ſolution has been ſo much ſought for by mathematicians for 2000 years paſt; being, in this reſpect, on a footing with the famous quadrature of the circle, and the duplicature of the cube.

TRISTAN D'ACUNHA, the largeſt of three iſlands which were viſited by Lord Macartney and his ſuite on the 31ſt of December 1792. The other two are diſtinguiſhed by the names of *Inacceſſible* and *Nightingale* iſlands. "Inacceſſible (as Sir Eraſmus Gower obſerved) ſeems to deſerve that name, being a high, bluff, as well as apparently barren plain, about nine miles in circumference, and has a very forbidding appearance. There is a high rock detached from it at the ſouth end. Its latitude is 37° 19′ ſouth; its longitude 11° 50′ weſt from Greenwich. This rude looking ſpot may be ſeen at 12 or 14 leagues diſtance. Nightingale iſland is irregular in its form, with a hollow in the middle, and is about ſeven or eight miles in circumference, with ſmall rocky iſles at its ſouthern extremity. It is deſcribed as having anchorage on the north-eaſt ſide. Its latitude is 37° 29′ ſouth; and longitude 11° 48′ weſt from Greenwich. It may be ſeen at ſeven or eight leagues diſtance. The largeſt of theſe three iſlands, which comparatively may be called the great iſle of *Triſtan d'Acunha*, is very high, and may be ſeen at 25 leagues diſtance. It ſeems not to exceed in circumference 15 miles. A part of the iſland towards the north riſes perpendicularly from the ſea to a height apparently of a thouſand feet or more. A level then commences, forming what among ſeamen is termed *table land*, and extending towards the centre of the iſland; from whence a conical mountain riſes, not unlike in appearance to the Peak of Teneriffe, as ſeen from the bay of Santa Cruz. Boats were ſent to ſound and to examine the ſhore for a convenient place to land and water. In conſequence of their report, the Lion (a ſhip of 64 guns) ſtood in, and came to anchor in the evening on the north ſides in 30 fathoms water, one mile from the ſhore; the bottom black ſand with ſlime; a ſmall rock, off the weſt point, bearing ſouth weſt by ſouth juſt open with the weſtern extremity of the iſland; a caſcade, or fall of water, emptying itſelf upon the beach, ſouth by eaſt. All the ſhore, from the ſouthern point to the eaſtern extremity, appears to be clear of danger, and ſteep, except the weſt point, where there are breakers about two cables length, or near 500 yards from the ſhore. The ſhip, when anchored, was overſhadowed by the dark maſs of that portion of the iſland whoſe ſides ſeemed to riſe, like a moſs-grown wall, immediately from the ocean. On the right the elevation was leſs rapid, and between the riſing part and the ſea was left a flat, of ſome extent, covered with ſedge graſs, interſperſed with ſmall ſhrubs, which, being perfectly green, looked from the ſhip like a pleaſant meadow, watered by a ſtream that fell, afterwards, from its banks upon the beach. The officers, who went aſhore, reported, that the caſks might be filled with freſh water by means of a long hoſe, without moving them from the boats. The landing place thereabouts was alſo deſcribed as being ſafe, and ſuperior to any other that had been examined. From the plain, the land roſe gradually towards the central mountain, in ridges covered with trees of a moderate ſize and height. The coaſt abounded with ſea lions and ſeals, penguins and albatroſſes. One of the latter was brought on board, his wings meaſuring ten feet from tip to tip; but others are ſaid to have been found much larger. The coaſt was covered with a broad ſea weed, ſeveral fathoms long, and deſervedly by naturaliſts termed *gigantic fucus*. Some good fiſh was caught with the hook and line.

"The accident of a ſudden guſt, by which the anchor was in a few hours driven from its hold, and the ſhip forced out to ſea, prevented the iſland from being explored, as was intended. It is probable that had the Lion anchored in 20, inſtead of 30 fathoms water, the anchor would have held firmly. Some advantage was obtained, however, from coming to this place. The juſt poſition of thoſe iſlands, in reſpect to their longitude, was aſcertained, by the mean of ſeveral timepieces, to be about two degrees to the eaſtward of the place where they are laid down in charts, taken from obſervations made at a period when the inſtruments for this purpoſe were leſs accurate than at preſent. The ſpot where the Lion anchored was determined, by good meridional obſervations, and by accurate time-pieces, to be 37° 6′ ſouth latitude, and 11° 43′ weſt longitude from Greenwich. The compaſs had ſeven degrees of variation weſtward from the pole. Fahrenheit's thermometer ſtood at 67 degrees. It was uſeful alſo to have aſcertained, that a ſafe anchorage and plenty of good water, were to be found here. Theſe iſlands are certainly worthy of a more particular inquiry; for they are not 50 leagues from the general track of veſ-

sels bound to China, and to the coast of Coromandel, by the outer passage. In war time, an excellent rendezvous might be settled there, for ships that wanted no other supply but that of water. When circumstances require particular dispatch, it is practicable to come from England to Tristan d'Acunha without stopping in the way, and afterwards to the end of the voyage to India or China."

These islands are separated by a space of about fifteen hundred miles from any land to the westward or northward of them. They are situated in that part of the southern hemisphere, in the neighbourhood of which a continent, to balance the quantity of land in the northern hemisphere, was once expected to be found, but where it has been since discovered that there is none. Of what extent, however, the bases of these islands are under the surface of the sea, cannot be ascertained; or whether they may, or may not, be sufficient to make up for the defect of land appearing above water. Navigators report, that to the eastward of them are other small islands, differing not much in latitude, such as Gough and Alvarez islands, and the Marsouines; as well as extensive shoals, lying due south of the most southerly point of Africa, and extending easterly several degrees. That all these together form a chain, some of subaqueous, and some of superaqueous mountains, but all connected by their roots, is perhaps a conjecture less improbable, than that they should separately arise, like tall columns, from the vast abyss.

A settlement in Tristan d'Acunha is known to have been twice in the contemplation of adventurers, but not as yet to have been carried into execution. One had the project of rendering it a mart for the change of the light manufactures of Hindostan, suited to hot climes, for the silver of the Spanish settlements in South America; in the route between which places it is conveniently situated. The other plan meant is only as a suitable spot for drying and preparing the furs of sea lions and seals, and for extracting the spermaceti of the white or long nosed whale, and the whale-bone and oil of the black species. Whales of every kind were seen sporting about Tristan d'Acunha, particularly near the setting of the sun; and the sword fish likewise made its appearance occasionally.—*Sir George Staunton's Account of the Embassy to China.*

TRITON, in zoology, a genus belonging to the order of vermes mollusca. The body is oblong; the tongue is spiral; it has twelve tentacula, six on each side, the hindmost ones having claws like a crab. There is but one species, found in holes of rocks about the shore.

TROTTER (Mrs Catharine), was the daughter of Captain David Trotter, a Scotch gentleman. He was a commander in the royal navy in the reign of Charles II. and at his death left two daughters, the youngest of whom, Catharine, our celebrated author, was born in London, August 1679. She gave early marks of her genius; and learned to write, and also made herself mistress of the French language, by her own application and diligence, without any instructor; but she had some assistance in the study of the Latin grammar and logic, of which latter she drew up an abstract for her own use. The most serious and important subjects, and especially religion, soon engaged her attention.—But notwithstanding her education, her intimacy with several families of distinction of the Romish persuasion, exposed her, while very young, to impressions in favour of that church; which not being removed by her conferences with some eminent and learned members of the church of England, she embraced the Romish communion, in which she continued till the year 1707. In 1695, she produced a tragedy called *Agnes de Castro*, which was acted at the theatre-royal when she was only in her 17th year. The reputation of this performance, and the verses which she addressed to Mr Congreve upon his Mourning Bride, in 1697, were probably the foundation of her acquaintance with that celebrated writer. Her second tragedy, *Fatal Friendship*, was acted in 1698, at the new theatre in Lincoln's-Inn-Fields. This tragedy met with great applause, and is still thought the most perfect of her dramatic performances. Her dramatic talents not being confined to tragedy, she brought upon the stage, in 1701, a comedy called *Love at a loss*, or *Most votes carry it*. In the same year she gave the public her third tragedy, entitled the *Unhappy Penitent*, acted at the theatre royal in Drury-lane. But poetry and dramatic writing did not so far engross the thoughts of our author but that she sometimes turned them to subjects of a very different nature; and distinguished herself in an extraordinary manner in defence of Mr Locke's writings; a female metaphysician being a remarkable phenomenon in the republic of letters.

She returned to the exercise of her dramatic genius in 1703, and fixed upon the revolution of Sweden, under Gustavus Erickson, for the subject of a tragedy. This tragedy was acted, in 1706, at the Queen's theatre in the Hay-Market. In 1707, her doubts concerning the Romish religion, which she had so many years professed, having led her to a thorough examination of the grounds of it, by consulting the best books on both sides of the question, and advising with men of the best judgment, the result was a conviction of the falseness of the pretensions of that church, and a return to that of England, to which she adhered during the remainder of her life. In 1708, she was married to the Rev. Mr Cockburn, then curate of St Dunstan's in Fleet-street, but he afterwards obtained the living of Long-Horsely, near Morpeth in Northumberland. He was a man of considerable abilities; and, among several other things, wrote an account of the Mosaic Deluge, which was much approved by the learned.

Mrs Cockburn's remarks upon some writers in the controversy concerning the foundation of moral duty and moral obligation, were introduced to the world, in August 1743, in the Literary Journal, intitled *The History of the Works of the Learned.* The strength, clearness, and vivacity shewn in her remarks upon the most abstract and perplexed questions, immediately raised the curiosity of all good judges about the concealed writer; and their admiration was greatly increased when her sex and advanced age were known. Dr Rutherforth's Essay on the Nature and Obligations of Virtue, published in May 1744, soon engaged her thoughts; and notwithstanding the asthmatic disorder, which had seized her many years before, and now left her small intervals of ease, she applied herself to the confutation of that elaborate discourse, and finished it with a spirit, elegance, and perspicuity equal, if not superior, to all her former writings.

The loss of her husband in 1748, in the 71st year of his age, was a severe shock to her; and she did not long survive him, dying on the 11th of May 1749, in her

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71st year, after having long supported a painful disorder with a resignation to the Divine will, which had been the governing principle of her whole life, and her support under the various trials of it.

Her works are collected into two large volumes 8vo, by Dr Birch; who has prefixed to them an account of her life and writings.

TRUMPET Marine, or Marigny. This is a stringed instrument, invented in the 16th century by an Italian artist Marino or Marigni, and called a *trumpet*, because it takes only the notes of the trumpet, with all its omissions and imperfections, and can therefore execute only such melodies as are fitted for that instrument. It is a very curious instrument, though of small musical powers, because its mode of performance is totally unlike that of other stringed instruments; and it deserves our very particular attention, because it lays open the mechanism of musical sounds more than any thing we are acquainted with; and we shall therefore make use of it in order to communicate to our readers a philosophical theory of music, which we have already treated in detail as a liberal or scientific art.

Plate XLV.

The trumpet marine is commonly made in the form of a long triangular pyramid, ABCD, fig. A. on which a single string EFG is strained over a bridge F by means of the finger pin L. At the narrow end are several frets 1, 2, 3, 4, 5, &c. between E and K, which divide the length EF into aliquot parts. Thus E 1 is $\frac{1}{12}$ of EF, E 2 is $\frac{1}{11}$, and so on. The bow is drawn lightly across the cord at H, and the string is stopped by pressing it with the finger immediately above the frets, but not so hard as to make it touch the fret. When the open string is sounded, it gives the fundamental note. If it be stopped, in the way now described, at $\frac{1}{3}$d of its length from E, it yields the 12th of the fundamental; if stopped at $\frac{1}{4}$th, it gives the double octave; if at $\frac{1}{5}$th, it gives the 17th major, &c. In short, it always gives the note corresponding to the length of the part between the fret and the nut E. The sounds resemble those of a pipe, and are indeed the same with those known by the name *harmonics*, and now executed by every performer on instruments of the viol or violin species. But in order to increase the noise, the bridge F is constructed in a very particular manner. It does not rest on the sound-board of the instrument through its whole breadth, but only at the corner *a*, where it is firmly fixed. The other extremity is detached about $\frac{1}{100}$ of an inch from the sound board; and thus the bridge, being made to tremble by the strong vibration of the thick cord, rattles on the sound-board, or on a bit of ivory glued to it. The usual way in which this motion is procured, is to have another string passing under the middle of the bridge in such a manner that, by straining it tight, we raise the corner *b* from the sound-board to the proper height. This contrivance increases prodigiously the noise of the instrument, and gives it somewhat of the smart sound of the trumpet, tho' very harsh and coarse. But it merits the attention of every person who wishes to know any thing of the philosophy of musical sounds, and we shall therefore say as much on the subject as will conduce to this effect.

Galileo, as we have observed in the article Temperament, *Suppl.* was the first who discovered the real connection between mathematics and music, by demonstrating that the times of the vibrations of elastic cords of the same matter and size, and stretched by equal weights, are proportional to the lengths of the strings. He inferred from this that the musical pitch of the sound produced by a stretched cord depended solely on the frequency of the vibrations. Moreover, not being able to discover any other circumstance in which those sounds physically resembled each other, and reflecting that all sounds are immediately produced by agitations of air acting on the ear, he concluded that each vibration of the cord produced a sonorous pulse in the air, and therefore that the pitch of *any* sound whatever depended on the frequency of the aerial pulses. In this way alone the sound of a string, of a bell, of an organ pipe, and the bellow of a bull, may have the same pitch. He could not, however, demonstrate this in any case but the one above mentioned. But he was encouraged to hope that mathematicians would be able to demonstrate it in all cases, by his having observed that the same proportions obtained in organ pipes as in strings stretched by equal weights. But it required a great progress in mechanical philosophy, from the state in which Galileo found it, before men could speculate and reason concerning the pulses of air, and discover any analogy between them and the vibrations of a string. This analogy, however, was discovered, and its demonstration completed, as we shall see by and by. In the mean time, Galileo's demonstration of the vibrations of elastic cords became the foundation of all musical philosophy. It must be thoroughly understood before we can explain the performance of the trumpet marine.

The demonstration of Galileo is remarkable for that beautiful simplicity and perspicuity which distinguish all the writings of that great mechanician, and it is the elementary proposition in all mechanical treatises of music. Few of them indeed contain any thing more; but it is extremely imperfect, and is just only on the supposition that all the matter of the string is collected at its middle point, and that the rest of it has elasticity without *inertia*. This did not suit the accurate knowledge of the last century, after Huyghens and Newton had given the world a taste of what might be done by prosecuting the Galilean mechanics. When a musical cord has its middle point drawn aside, and it is strained into the shape of two strait lines, if it be let go will be observed not to vibrate in this form. It may easily be seen in the extremity of its excursions, where it rests, before it return by its elasticity. The reason is this (see fig. B.) When the middle point C of the cord is drawn aside, and the cord has the form of two straight lines AC, CB, this point C, being pulled in the directions CA, CB, at once, is really accelerated in the direction CD, which bisects the angle ACB; and if it were then detached from the rest of the material cord, it would move in that direction. But any other point *f* between C and B has no accelerating force whatever acting on it. It is equally pulled in the directions *f*C and *f*B. The particle C therefore is obliged to drag along with it the inert matter of the rest of the cord; and when it has come to any intermediate situation *c*, the cord cannot have the form of two straight lines A *c*, *c* B, with the particle *f* situated in *'f*. This particle will be left somewhat behind, as in *r*, and the cord will have a curved form A *c r* B; and in this form it will vibrate, going to the other side, and assuming, not the rectilineal form ADB, but the curved form A*δ*B.

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Ac'B. That every particle of the curve A$e c'f$B is now accelerated toward the axis AB is evident, because every part is curved, and the whole is strained toward A and B, which tends to straighten every part of it. But in order that the whole may arrive at the axis in one moment, and constitute a straight line AB, it is evidently necessary that the accelerating force on every particle be as the distance of the particle from that point of the axis at which it arrives. It is well known to the mathematician that the accelerating force by which any particle is urged towards a rectilineal position, with respect to the adjoining particles, is proportional to the curvature. Our readers who are not familiar with such discussions, may see the truth of this fundamental proposition by considering the whole of AcB as only a particle or minute portion of a curve, magnified by a microscope. The force which strains the curve may be represented by cA or AE. Now it is well known (and is the foundation of Galileo's demonstration) that the straining force is to the force with which c is accelerated in the direction cE as Ac to cD, or as AE to cD, or as AE to twice cE. Now cE is the measure of the curvature of AcB, being its deflection from a right line. Therefore when the straining force is the same all over the curve, the accelerating force, by which any portion of it tends to become straight, is proportional to the curvature of that portion. And if r be the radius of a circle passing through A, c, and B, and coinciding with this element of a curve, it is plain that $cD : cA = cA : r$, or that the radius of curvature is to the element cA as the extending force to the accelerating force; and $cD = \frac{cA^2}{r}$; and is inversely as r, or directly as the curvature.

Hence we see the nature of that curve which a musical chord must have, in order that all its parts may arrive at the axis at once. The curvature at c must be to the curvature at f as Ec to gf. But this may not be enough. It is farther necessary that when c has got half way to E, the curvature in the different points of the new curve into which the cord has now arranged itself, be also, in every point, proportional to the distance from the axis. Now this *will* be the case if the extreme curve has been such. For, taking the cord in any other successive shape, the distance which each point has gone in the same moment must be proportional to the force which impelled it; therefore the remaining distances of all the points from the axis will have the same proportions as before. And the geometrical and evident consequence of this is, that the curvatures will also be in the same proportion.

Therefore a cord that is once arranged in this form will always preserve it, and will vibrate like a cycloidal pendulum, performing its oscillations in equal times, whether they be wide or narrow. Therefore since this perfect isochronism of vibrations is all that is wanted for preserving the same musical pitch or tone, this cord will always have the same note.

This proposition was the discovery of Dr Brooke Taylor, one of the ornaments of our country *, and is published in his celebrated work *Methodus Incrementorum*. The investigation, however, and the demonstration in that work, are so obscure and so tedious that few had patience to peruse them. It was more elegantly treated afterwards by the Bernoullis and others. The curve got the name of the *Taylorean curve;* and is considered by many eminent mathematicians as a trochoid, *viz.* the curve described by a point in the nave or spoke of a wheel while the wheel rolls along a straight line. But this is a mistake, although it is allied to the trochoid in the same manner that the figure of sines is allied to the cycloid. Its physical property intitles it to the name of the HARMONICAL CURVE. As this curve is not only the foundation of all our knowledge of the vibration of elastic cords, but also furnishes an equation which will lead the mathematician through the whole labyrinth of aereal undulations, and be of use on many other occasions; and as the first mathematicians have, through inattention, or through enmity to Dr Taylor, affected to consider it as the trochoid already well known to themselves—we shall give a short account of its construction and chief properties, simplified from the elegant description given by Dr Smith in his Harmonics.

* See his life, *Encycl.*

Let SDTV, QERP (fig. C.), be circles described round the centre C. Draw the diameters QCR, ECP, cutting each other at right angles. From any point G in the exterior circle draw the radius GC, cutting the interior circle in F, draw KHFI parallel to QCR, and make HI, HK, each equal to the arch EG. Let this be done for every point of the quadrantal arch EGR. The points I, K, are in the harmonic curve; that is, the curve AKDIB passing through the points K and I, determined by this construction, has its curvature in every point K proportional to the distance KN from the base AB.

To demonstrate this, draw FL perpendicular to the axis, and join EL. Take another point g in the outer circle indefinitely near to G. Draw gc, cutting the inner circle in f, and fh and fl perpendicular to DC, CP, and join El. Then suppose two lines Km', Km' perpendicular to the curve in K and k. They must meet in m, the centre of the equicurve circle. Draw KNn' perpendicular to the base, and $m'n'$ parallel to it, and join kn. Lastly, draw Xix perpendicular to EL.

It is plain that kO, the difference of HK and hk, is equal to Gg, the difference of GE and gE, and that KO is equal to Fr, and Ll to rf. Also, because ELX is a right angle, $EX = \frac{EL^2}{EC}$.

We have $Fr : Ff = CL : CF, = CL : CD.$

$Ff : Gg = CD : CE.$

Therefore $Fr : Gg$, or $KO : Ok = CL : CE$.

The triangles ECL and kOK are therefore similar, as are also kOK and Knm, and consequently ECL and Knm; and because EC is parallel to Kn, EL is parallel to Km. For the same reason km is parallel to El, and the triangles Elx and mKk are similar, and

$Lx : Kk = LE : Km,$

and $Lx : Kk = EC : Kn$. But farther,

$Lx : Ll = CE : CL$

$Ll : Ff = KN : CD$, being $= FL : FC$

$Ff : Gg = CD : CE$, being $= Ff : kO$

$Gg : Kk = CE : CL$; being $= KO : Kk$.

Therefore $Lx : Kk = KN \times CE : EL^2, = KN : EX$.

Therefore $KN : EX = LE : Km$, and $Km = \frac{EX \cdot LE}{KN}$

and $KN : EX = CE : Kn$, and $Kn = \frac{EX \cdot CE}{KN}$

In

In the very narrow vibrations of musical cords, CD is exceedingly small in comparison with CE, so that EX·EL, or EX·CE, may, without sensible error, be taken for CE^2, and then we obtain Km or Kn (which hardly differ) $= \frac{CE^2}{KN}$, and therefore the curvature is proportional to KN. The small deviation from this ratio would seem to shew that this construction does not give the harmonic curve with accuracy. But it is not so. For it will be found that although the curvature is not as KN, it is still proportional to the space which any particle K must really describe in order to arrive at the axis. These paths are lines whose curvatures diminish as they approach to DC.

We see, *1st*, that the base ACB of the curve is equal to the semicircular arch QER.

2d, Also that the tangent KZ in any point K is perpendicular to EL.

3d. We learn that the curvature at A and B is nothing, for in these two points KN is nothing.

4th, The radius of curvature at D is precisely $= \frac{CE^2}{CD}$.

Therefore, as the string approaches the axis, and CD diminishes, the curvature diminishes in the same proportion. The vibrations therefore are performed like those of a pendulum in a cycloid, and are isochronous, whether wide or narrow, and therefore the musical pitch is constant.

This is not strictly true, because in the wide vibrations the extension or extending force is somewhat greater. Hence it is that a string when violently twanged sounds a little sharper at the beginning. Dr Long made a harpsichord whose strings were stretched by weights, by which this imperfection was removed.

It is proper to exhibit the curvature at D in terms of the length AB, and of the greatest excursion c D. Therefore let c be the circumference of a circle whose diameter is 1. Let AB the length of the cord be $=$ L, and let CD the $\frac{1}{2}$ breadth of the vibration be B.

We had a little ago $Dm = \frac{CE^2}{CD}$, but $c : 1 = AB$: CE, and $CE = \frac{AB}{c}$, and $cE^2 = \frac{ABc}{c^2}$. Therefore Dm $= \frac{AB^2}{c^2 \times CD}, = \frac{L^2}{9{,}87CD}$ nearly.

We can now tell the number of vibrations made in a second by a string. This we obtain by comparing its motion, when impelled by the accelerating force which acts on it, with its motion when acted on by its weight only. Therefore let L be the length of a string, and W its weight, and let E be the straining weight, or extending force. Let f be the force which accelerates the particle Dd of the cord, and w the weight of that particle, while W is the weight of the whole cord. Let z the space which the particle Dd would describe during the time of one vibration by the uniform action of the force f, and let S be the space which it would describe in the same time by its weight w alone. Then (Dynamics, *Suppl.* n° 103. cor. 6.) the time in which f would impel the particle Dd along $\frac{1}{2}$ DC, is to the time of one vibration as $1 : c$. And $\frac{1}{2}$ DC is to z as the square of the time of describing $\frac{1}{2}$ DC, is to the square of the time of describing z; that is, $1 : c^2 = \frac{1}{2}DC : 2z$, and $c^2.DC = 2z$.

Now, by the property of the harmonic curve,

$$AB : Dm = 2z : AB$$
$$\text{But } Dm : Dd = E : f$$
$$\text{And } Dd : AB = w : W$$
$$\text{Therefore } 2z \cdot E \cdot w = AB \cdot f \cdot W$$
$$\text{And } f : w = 2z \times E : AB \times W$$
$$\text{But } w : f = 2S : 2z$$
$$\text{Therefore } 2S \times E = AB \times W$$
$$\text{And } 2E : W = AB : S.$$

That is, a musical cord, extended by a force E, performs one vibration DCV in the time that a heavy body describes a space S, which is to the length of the cord as its weight is to twice the extending force.

Now let g be the space through which a heavy body falls in one second, and let the time of a vibration (estimated in parts of a second) be T. We have

$$AB : S = 2E : W$$
$$S : g = T^2 : 1^2$$
$$\text{Therefore } AB : g = 2E \cdot T^2 : W$$
$$\text{And } AB \times W = T^2 \times 2E \times g$$
$$\text{Therefore } T^2 = \frac{AB \times W}{2g.E}, \text{ and } T = \sqrt{\frac{AB \times W}{2g.E}}$$

Let n be the number of vibrations made in a second.

$$n = \frac{1}{T}, = \sqrt{\frac{2g.E}{AB.W}} = \sqrt{\frac{2g\,E}{L.W}}.$$

If the length of the cord be measured in feet, $2g$ is very nearly 32. If in inches, $2g$ is 386, more nearly. Therefore $n = \sqrt{\frac{32\,E}{L \cdot W}}$ or $\sqrt{\frac{386\,E}{L \cdot W}}$. This may easily be compared with observation. Dr Smith hung a weight of 7 pounds, or 49,000 grains, on a brass wire suspended from a finger pin, and shortened it till it was in perfect unison with the double octave below the open string D of a violin. In this state the wire was 35,55 inches long, and it weighed 31 grains.

Now $\sqrt{\frac{384 \times 49000}{35{,}55 \times 31}} = 130{,}7 = n$. This wire, therefore, ought to make 130,7 vibrations in a second. Dr Smith proceeded to ascertain the number of aereal pulses made by this sound, availing himself of the theory of the beats of tempered consonances invented by himself. On his fine chamber organ he tuned upwards the perfect fifths DA, A e, e b, and then tuned downward the perfect 6th e d. Thus he obtained an octave to D, which was too sharp by a comma, and he found that it beat 65 times in 20 seconds. Therefore the number of vibrations was $\frac{65}{20}$ 81, or 263,25. These were complete pulses or motions from D to V and back again, and therefore contained 526½ such vibrations as we have now been considering. The double octave below should make ¼th of this, or 131,6, which is not a complete vibration more than the above theory requires: more accurate coincidence is needless.

This theory is therefore very completely established, and it may be considered as one of the finest mechanical problems which has been solved in this century. We mention it with the greater minuteness, because the merit of Dr Taylor is not sufficiently attended to. Mr Rameau, and the other great theorists in music, make no mention of him; and such as have occasion to speak of the absolute number of vibrations made by any musical note, always quote Mr Sauveur of the French academy.

2

demy. This gentleman has written some very excellent dissertations on the theory of music, and Sir Isaac Newton in his *Principia* often quotes his authority. He has given the actual determination of the number of vibrations of the note C, obtained in a manner similar to that practised by Dr Smith on his chamber organ, and which agrees extremely well with that measure. But Mr Sauveur has also given a mechanical investigation of the problem, which gives the same number of vibrations that he observed. We presume that Rameau and others took the demonstration for good; and thus Mr Sauveur passes on the Continent for the discoverer of this theorem. But it was not published till 1716, though read in 1713; whereas Dr Taylor's demonstration was read to the Royal Society in May 1714. But this demonstration of Mr Sauveur is a mere paralogism, where errors compensate errors; and the assumption on which he proceeds is quite gratuitous, and has nothing to do with the subject. Yet John Bernoulli, from enmity to Taylor and the English mathematicians, takes not the least notice of this sophisticated demonstration, accommodated to the experiment, and so devoid of any pretensions to argument that this severe critic could not but see its falsity.

Sauveur was one of the first who observed distinctly that remarkable fact which Mr Rameau made the foundation of his musical theory, *viz.* that a full musical note is accompanied by its octave, its twelfth, and its seventeenth major. It had been casually observed before, by Marsennus, by Perrault, and others; but Sauveur tells distinctly how to make the observation, and affirms it to be true in all deep notes. Rameau asserts it to be universally and necessarily true in all notes, and the foundation of all musical pleasure.

It had been discovered before this time, that not only a full note caused its unison to resound, but also that a 12th, being sounded near any open string, the string *resounded* to this 12th. It does the same to a 15th, a 17th major, a 22d, &c.

Dr Wallis added a very curious circumstance to this observation. Two of his pupils, Mr Noble and Mr Pigott, in 1673, amusing themselves with these resonances, observed, that if a small bit of paper be laid on the string of a violin which is made to resound to its unison, the paper is thrown off: a proof that the string resounded by really vibrating, and that it is thrown into these vibrations by the pulses of the air produced by the other string. In like manner the paper is thrown off when the string resounds to its octave. But the young gentlemen observed, that when the paper was laid on the middle point of the string, it remained without agitation, although the string still resounded. They found the same thing when they made the string resound to its 12th: papers laid on the two points of division lay still, but were thrown off when laid on any other place. In short, they found it a general rule, that papers laid on any points of division corresponding to the note which was resounded, were not agitated.

Dr Wallis (the greatest theorist in music of the last century) justly concluded that these points of the resounding string were at rest, and that the intermediate parts were vibrating, and producing the notes corresponding to their lengths.

From this Mr Sauveur, with great propriety, deduced the theory of the performance of the trumpet marine, the vielle, the clavichord, and some other instruments.

When the string of the trumpet marine is gently stopped at $\frac{1}{2}$, and the bow drawn lightly across it at H (fig. A), the full vibration at the finger is stopped; but the string is thrown into vibrations of some kind, which will either be destroyed or may go on. It is of importance to see what circumstance will permit their continuance.

Suppose an elastic cord put into the situation ABCDE (fig. D), such that AB, BC, CD, DE, are all equal, and that BCD is a straight line. Let the point C be made fast, and the two points B and D be let go at once. It is evident that the two parts will immediately vibrate in two harmonical curves A*b*C and CDE, which will change to ABC and C*d*E, and so on alternately. It is also evident that if a line FCG be drawn touching the curve ABC, it will also touch the curve CDE; and the line which touches the curve A*b*C in C, will also touch the curve C*d*E. In every instant the two halves of the cord will be curves which have a common tangent in the point C. The undoubted consequence of this is, that the point C will not be affected by these vibrations, and its fixure may be taken away. The cord will continue to vibrate, and will give the sound of the octave to its fundamental note.

The condition, then, which must be implemented, in order that a string may resound to its octave, or take the sound of its octave, is simply this, that its two parts may vibrate equally in opposite directions. This is evidently possible; and when the bow is drawn across the string of the trumpet marine at H, and irregular vibrations are produced in the whole string, those which happen to be in one direction on both sides of the middle point, where it is gently stopped by the finger, will destroy each other, and the conspiring ones will be instantly produced, and then every succeeding action of the bow will increase them.

The same thing must happen if a string is gently stopped at one-third of its length; for there will be the same equilibrium of forces at the two points of division, so that the fixures of these points may be removed, and the string will vibrate in three parts, sounding the 12th of the fundamental.

We may observe, by the way, that if the bow be drawn across the string at one of the points of division, corresponding to the stopping at the other end of the string, it will hardly give any distinct note. It rattles, and is intolerably harsh. The reason is plain: The bow takes some hold of the point C, and drags it along with it. The cord on each side of C is left behind, and therefore the two curves cannot have a common tangent at C. The vibrations into which it is thus jogged by the bow destroy each other.

We now see why the trumpet marine will not sound every note. It will sound none but such as correspond to a division of the string into a number of equal parts, and its note will be in unison with a string equal to one of those parts. Therefore it will *first* of all sound the fundamental, by its whole length;

2. Its octave, corresponding to its length
3. The 12th, - - -
4. The 15th, or double octave, $\frac{1}{4}$
5. The 17th, - - - $\frac{1}{5}$
6. The 19th, - - $\frac{1}{6}$

7. The

Musical Trumpet

7. The 21st, which is not in the diatonic scale of our music, - $\frac{1}{7}$ its length.
8. The triple octave, or 22d, - $\frac{1}{8}$
9. The 23d, or 2d in the scale of the triple octave - - - $\frac{1}{9}$
10. The 24th, or 3d in this scale, $\frac{1}{10}$
11. The 25th, a false 4th of this scale, $\frac{1}{11}$
12. The 26th, a perfect 5th of this scale, $\frac{1}{12}$
13. The 27th, a false 6th of ditto, $\frac{1}{13} = \frac{1}{13}$ or [illegible]
14. The 28th, a false 7th minor, - $\frac{1}{14}$
15. The 28th, a perfect 7th major, $\frac{1}{15}$
16. The quadruple octave, - $\frac{1}{16}$

Thus we see that this instrument will not execute all music, and indeed will not complete any octave, because it will neither give a perfect 4th nor 6th. We shall presently see that these are the very defects of the trumpet.

This singular stringed instrument has been described in this detail, chiefly with the view of preparing us for understanding the real trumpet. The VIELLE, SAVOYARDE, or HURDYGURDY, performs in the same manner. While the wheel rubs one part of the string like a bow, the keys gently press the strings, in points of aliquot division, and produce the harmonic notes.

It is to prevent such notes that the part of harpsichord wires, lying between the bridge and the pins, are wrapped round with list. These notes would frequently disturb the music.

Lastly on this head, the Æolian harp derives its vast variety of fine sounds from this mode of vibration. Seldom do the cords perform their fundamental or simple vibrations. They are generally sounding some of the harmonics of their fundamentals, and give us all this variety from strings tuned in unison.

TRUMPET, Musical, is a wind instrument which sounds by pressing the closed lips to the small end, and forcing the wind through a very narrow aperture between the lips. This is one of the most ancient of musical instruments, and has appeared in all nations in a vast variety of forms. The conch of the savage, the horn of the cowherd and of the postman, the bugle horn, the lituus and tuba of the Romans, the military trumpet, and the trombone, the *cor de chasse* or French horn—are all instruments winded in the same manner, producing their variety of tones by varying the manner and force of blowing. The serpent is another instrument of the same kind, but producing part of its notes by means of holes in the sides.

Although the trumpet is the simplest of all musical instruments, being nothing but a long tube, narrow at one end and wide at the other, it is the most difficult to be explained. To understand how sonorous and regulated undulations can be excited in a tube without any previous vibration of reeds to form the waves at the entry, or of holes to vary the notes, requires a very nice attention to the mechanism of aereal undulations, and we are by no means certain that we have as yet hit on the true explanation. We are certain, however, that these aereal undulations do not differ from those produced by the vibration of strings; for they make strings resound in the same manner as vibrating cords do. Galileo, however, did not know this argument for his assertion that the musical pitch of a pipe, like that of a cord, depended on the frequency alone of the aereal undulations; but he thought it highly probable, from his observations on the structure of organs, that the notes of pipes were related to their lengths in the same manner as those of wires, and he expressly makes this remark. Newton, having discovered that sound moved at the rate of about 960 feet per second, observed that, according to the experiments of Mr Sauveur, the length of an open pipe is half the length of an aereal pulse. This he could easily ascertain by dividing the space described by sound in a second by the number of pulses.

Daniel Bernoulli, the celebrated promoter of the Newtonian mechanics, discovered, or at least was the first who attentively marked, some other circumstances of resemblance between the undulations of the air in pipes and the vibrations of wires. As a wire can be made, not only to vibrate in its full length, sounding its fundamental note, but can also be made to subdivide itself, and vibrate like a portion of the whole, with points of rest between the vibrating portions, when it gives one of its harmonic notes; so a pipe cannot only have such undulations of air going on within it as are competent to the production of its fundamental note, but also those which produce one of its harmonic notes. Every one knows that when we force a flute, by blowing too strongly, it quits its proper note, and gives the octave above. Forcing still more, produces the 12th. Then we can produce the double octave or 15th, and the 17th major, &c. In short, by attending to several circumstances in the manner of blowing, all the notes may be produced from one very long pipe that we produce from the trumpet marine, and in precisely the same order, and with the same omissions and imperfections. This alone is almost equivalent to a proof that the mechanism of the undulations of air in a pipe are analogous to that of the vibrations of an elastic cord. Having with so great success investigated the mechanism of the partial vibrations of wires, and also another kind of vibrations which we shall mention afterwards, incomparably more curious and more important in the philosophy of musical sounds, Mr Bernoulli undertook the investigation of those more mysterious motions of air which are produced in pipes; and in a very ingenious dissertation, published in the Memoirs of the Academy of Paris for 1762, &c. he gives a theory of them, which tallies in a wonderful manner with the chief phenomena which we observe in the wind instruments of the flute and trumpet kind. We are not, however, so well satisfied with the truth of his *assumptions* respecting the state of the air, and the precise form of the undulations which he assigns to it; but we see that, notwithstanding a probability of his being mistaken in these circumstances (it is with great deference that we presume to suppose him mistaken), the chief propositions are still true; and that the changes from note to note must be produced in the order, tho' perhaps not in the precise manner, assigned by him.

It is by no means easy to conceive, with clearness, the way in which musical undulations are excited in the various kinds of trumpets. Many who have reputation as mechanicians, suppose that it is by means of vibrations of the lips, in the same manner as in the hautboy, clarionette, and reed pipes of the organ, where the air, say they, is put in motion by the trembling reed. But this explanation is wrong in all its parts; even in the reed pipes of an organ, the air is not put in motion by the reeds. They are indeed the *occasions* of its musical undulation, but they do not *immediately impel* it into

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into those waves. This method (and indeed all methods but the vibrations of wires, bells, &c.) of producing sound is little understood, though it is highly worthy of notice, being the origin of animal voice, and because a knowledge of it would enable the artists to entertain us with sounds hitherto unknown, and thus add considerably to this gift of our Bountiful Father, who has shewn, in the structure of the larynx of the human species, that he intended that we should enjoy the pleasures of music as a *laborum dulce lenimen*. He has there placed a micrometer apparatus, by which, *after* the other muscles have done their part in bringing the glottis nearly to the tension which the intended note requires, we can easily, and instantly, adjust it with the utmost nicety.

We trust, therefore, that our readers will indulge us while we give a very cursory view of the manner in which the tremulous motion of the glottis, or of a reed in an organ pipe, produces the sonorous undulations with a constant or uniform frequency, so as to yield a musical note.

If we blow through a small pipe or quill, we produce only a whizzing or hissing noise. If, in blowing, we shut the entry with our tongue, we hear something like a solid blow or tap, and it is accompanied with some faint perception of a musical pitch, just as when we tap with the finger on one of the holes of a flute when all the rest are shut. We are then sensible of a difference of pitch according to the length of the pipe; a longer pipe or quill giving a graver sound. Here, then, is like the *beginning* of a sonorous undulation. Let us consider the state of the air in the pipe: It was filled by a column of air, which was moving forward, and would have been succeeded by other air in the same state. This air was therefore nearly in its state of natural density. When the entry is suddenly stopped by the tongue, the included air, already in motion, conti- its motion. This it cannot do without growing rarer, and then it is no longer a balance for the pressure of the atmosphere. It is therefore retarded in its motion, totally stopped (being in a rarefied state), and is then pressed back again. It comes back with an accelerated motion, and recovers its natural density, while the state of rarefaction goes forward through the open air like any other aereal pulse. Its motions are somewhat, but not altogether, like that of a spiral wire, which has been in like manner moving uniformly along the pipe, and has been stopped by something catching hold of its hindermost extremity. This spring, when thus catched behind, stretches itself a little, then contracts *beyond* its natural state, and then expands again, quivering several times. It can be demonstrated that the column of air will make but one quiver. Suppose this accomplished in the hundredth part of a second, and that at that instant the tongue is removed for the hundredth part of a second, and again applied to the entry of the pipe. It is plain that this will produce such another pulse, which will join to the former one, and force it out into the air, and the two pulses together will be like two pulses produced by the vibration of a cord. If, instead of the tongue, we suppose the flat plate of an organ-reed to be thus alternately applied to the hole and removed, at the exact moments that the renewals of air are wanted, it is plain that we shall have *sonorous* undulations of *uniform* frequency, and therefore a musical note. This is the way in which reeds produce their effect, not by *impelling* the air into alternate states of motion to and fro, and alternate strata of rarefied and condensed air, but by giving them time to acquire this state by the combination of the air's elasticity with its progressive motion.

The adjustment of the succeeding puff of air to the pulse which precedes it, so that they may make — smooth and regular pulse, is more exact than we have yet remarked; for the stoppage of the hole not only *occasions* a rarefaction *before it*, but by checking the air which was just going to enter, makes a condensation *behind the door* (so to speak); so that, when the passage is again opened, the two parcels of air are fitted for supporting each other, and forming one pulse.

Suppose, in the next place, that the reed, instead of completely shutting the hole each time, only half shuts it. The same thing must still happen, although not in so remarkable a degree. When the passage is contracted, the supply is diminished, and the air now in the pipe must rarefy, by advancing with its former velocity. It must therefore retard; by retarding, regain its former density; and the air, not yet got into the pipe, must condense, &c. And if the passage be again opened or enlarged in the proper time, we shall have a complete pulse of condensed and rarefied air; and this must be accompanied by the beginning of a musical note, which may be continued like the former.

This will be a softer or more mellow note than the other; for the condensed and rarefied air will not be so suddenly changed in their densities. The difference will be like the difference of the notes produced by drawing a quill along the teeth of a comb, and that produced by the equally rapid vibrations of a wire. For let it be remarked here, that musical notes are by no means confined, as theorists commonly suppose, to the regular cycloidal agitations of air, such as are produced by the vibrations of an elastic cord; but that any crack, snap, or noise whatever, when repeated with sufficient frequency, becomes *ipso facto* a musical sound, of which we can tell the pitch or note. What can be less musical than the solitary cracks or snaps made by a stiff door when very slowly opened? Do this briskly, and the creak changes to a chirp, of which we can tell the note. The sounds will be harsh or smooth, according as the snaps of which they are composed are abrupt or gradual.

This distinction of sounds is most satisfactorily firmed by experiment. If the tongue of the organ ree quite flat, and if, in its vibrations, it apply itself t whole margin of the hole at once, so as complet shut it (as is the case in the oldfashioned regal the organ), the note is clear, smart, and harsh or but if the lips of the reed are curved, or the t properly bent backward, so that it applies itself t edges of the hole *gradatim*, and never completely the passage, the note may have any degree of m sweetness. This remark is worth the attention of instrument-makers or organ builders, and enables th to vary the VOICE of the organ at pleasure. We only mention it here as introductory to the explanation of the sounds of the trumpet.

We trust that the reader now perceives how the air, proceeding along a pipe, may be put in the state of alternate strata of condensed and rarefied air, the particles, in the mean time, proceeding along the pipe with a very moderate velocity; while the *state of undulation* is propagated at the rate of eleven or twelve hundred feet

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feet in a second; just as we may sometimes see a stream of water gliding gently down a canal, while a wave runs along its surface with much greater rapidity.

It will greatly assist the imagination, if we compare these aëreal undulations with the undulations of water in an open canal. While the water is flowing smoothly along, suppose a sluice to be thrust up from the bottom quite to the surface, or beyond it. This will immediately cause a depression on the lower side of the sluice, by the water's going along the canal, and a heaping up of the water on the other side. By properly timing the motion of this sluice up and down, we can produce a series of connected waves. If the sluice be not pushed up to the surface but only one-half way, there will be the same succession of waves, but much smoother, &c. &c.

It is in this state, though not by such means, that the air is contained in a sounding trumpet. It is not brought into this state by any tremor of the lips. The trumpeter sometimes feels such a tremor; but whenever he feels it, he can no longer sound his note. His lips are painfully tickled, and he must change his manner of winding.

When blowing with great delicacy and care, the deepest notes of a French horn, or trombone, we sometimes can feel the undulations of the air in the pipe distinctly fluttering and beating against the lips; and it is difficult to hinder the lips from being affected by it: but we feel plainly that it is not the lips which are fluttering, but the air before them. We feel a curious instance of this when we attempt to whistle in concert. If our accompanier intonates with a certain degree of incorrectness, we feel something at our own lips which makes it impossible to utter the intended note. This happens very frequently to the person who is whistling the upper note of a greater third. In like manner, the undulations in a pipe react on the reed, and check its vibrations. For if the dimensions of a pipe are such that the undulations formed by the reed cannot be kept up in the pipe, or do not suit the length of the pipe, the reed will either not play at all, or will vibrate only in starts. This is finely illustrated by a beautiful and instructive experiment. Take a small reed of the *vox humana* stop of an organ, and set it in a glass foot, adapted to the windbox of the organ. Instead of the com pipe above it, fix on it the sliding tube of a small scope. When all the joints are thrust down, touch key, and look attentively to the play of the reed. While it is sounding, draw out the joints, making the pipe continually longer. We shall observe the reed thrown into strange fits of quivering, and sometimes quite motionless, and then thrown into wide sonorous vibrations, according as the *maintainable* pulse is com ite or not with the vibrations of the reed. This shews that the air is not impelled into its undu is by the reed, but that the reed accommodates it to the undulations in the pipe.

We acknowledge that we cannot explain with distinctness in what manner the air in a trumpet is first put into musical undulations. We see that it is only in very long and slender tubes that this can be done. In short tubes, of considerable diameter, like the cowherd's horn, we obtain only one or two very indistinct notes, of which it is difficult to name the pitch; this requires great force of blast; whereas, to bring out the deep notes of the French horn, a very gentle and well regulated blast is necessary. The form of the lips, combined with the force of the blast, form all the notes. But this is in a way that cannot be taught by any description. The performer learns it by habit, and *feels* that the instrument leaps into its note without him, when he gradually varies his blast, and continues sounding the same note; although he, in the mean time, makes some small change in his manner of blowing. This is owing to what Mr Bernoulli observed. The tube is suited only to such pulses, and can only maintain such pulses as correspond to aliquot parts of its length; and when the embouchure is very nearly, but not accurately, suited to a particular note, that note *forms itself* in the tube, and, reacting on the lips, brings them into the form which can maintain it with ease. We have a proof of this when we attempt to sound the note corresponding to one seventh of the length. Not having a distinct notion of this note, which makes no part of our scale of melody, we cannot easily prepare for it in the way that habit teaches us to prepare for the others: whereas, from what we shall see presently, the notes *one-sixth* and *one eighth* are both familiar to the mind, and easily produced. When, therefore, we attempt to produce the note *one-seventh*, we slide, against our will, into the *one sixth* or *one-eighth*.

Nor can we completely illustrate the formation of musical pulses by waves in water. A canal is equally susceptible of every height and length of progressive waves; whereas we see that a certain length of tube will maintain only certain determined pulses of air.

We must therefore content ourselves for the present with having learned, by means of the reed pipes, how the air may exist progressively in a tube, in an alternate state of condensation and rarefaction; and we shall now proceed to consider how this state of the air is related to the length of the tube. And here we can do no more than give an outline of Mr Bernoulli's beautiful theory of flutes and trumpets, but without a mathematical examination of the particular motions. We can, however, shew, with sufficient evidence, how the different notes are produced from the same tube. It requires, however, a very steady attention from the reader to enable him to perceive how the different portions of this air act on each other. We trust that this will now be given.

The conditions which must be implemented, in order to maintain a musical pulse, are two: 1. That the vibrations of the different plates of air be performed in equal times, otherwise they would all mix and confound each other. 2. That they move all together, all beginning and all ending at the same instant. It does not appear that any other state of vibration can exist and be maintained.

The column of air in a tube may be considered as a material spring (having weight and inertia) This spring is compressed and coiled up by the pressure of the atmosphere. But in this coiled state it can vibrate in its different parts, as a long spiral wire may do, though pressed a little together at the ends. It is evident that the air within a pipe, shut at both ends, may be placed in such a situation, *in a variety of ways*, that it will vibrate in every part, in the same manner as a chord of the same length and weight, strained by a force equal to the pressure of the atmosphere. Thus, in the shut pipe AB (fig. 1.), suppose a harmonic curve ACB, or a wire

Plate XLV.

a wire of the same weight with the air, throwing itself into the form of this curve. The force which impels the point C to the axis is to that which impels the point c as CE to ce. Now, suppose the air in this pipe divided into parallel strata or plates, crossing the tube like diaphragms. In order that these may vibrate in the same manner (not across the tube, but in the direction of its axis), all that is necessary for the moment is, that the excess of the pressure of the stratum dd above that of the stratum ff may be to the excess of the pressure of DD above that of FF as ce to CE. In this case, the stratum ce will be accelerated in the direction ef, and the stratum EE is accelerated in the same direction, and in the due proportion. Now this may be done in an infinite variety of ways for a single moment. It depends, not on the absolute density, but on the *variation* of density; because the pressure by which a particle of air is urged in any direction arises from the *difference* of the distances of the adjoining particles on each side of it. But in order to *continue* this vibration, or in order that it may obtain at once in the whole pipe, this variation of density must continue, and be according to some connected law. This circumstance greatly limits the ways in which the vibration may be kept up. Mr Bernoulli finds that the isochronism and synchronism can be maintained in the following manner, and in no other that he could think of:

Let AB (fig. 2.) be a cylindrical pipe, shut at A, and open at B. Then, in whatever manner the sound is produced in the pipe, the undulations of the contained air must be performed as follows: Let aa be a plate of air. This plate will approach to, and recede from, the shut end A, vibrating between the situations bb and cc, the whole vibration being bc, and the plate will vibrate like a pendulum in a cycloid. The greater we suppose the excursions ab, ac, the louder will the sound be; but the duration of them all must be the same, to agree with the fact that the tone remains the same. The motion will be accelerated in approaching to aa from either side, and retarded in the recess from it. Let us next consider a plate $\alpha\alpha$, more remote from A. It must make similar vibrations from the situation $\beta\beta$ to the situation $\gamma\gamma$. But these vibrations must be greater in proportion as the plate is farther from A. It cannot be conceived otherwise: For suppose the plate $\alpha\alpha$ to make the *same* excursions with aa, and that the rest do the same. Then they will all retain the same distances from each other; and thus there will be no force whatever acting on any particles to make them vibrate. But if every particle make excursions proportional to its distance from A, the *variation* of density will, in any instant, be the same through the whole pipe, and each particle in the vibrating plate $\beta\beta$ will be accelerated or retarded in proportion to its distance from A; while the accelerations and retardations over all will, in any instant, be proportional to the distance of each particle from its place of rest. All this will appear to the mathematician, who attentively considers any momentary situation of the particles. In this manner all the particles will support each other in their vibrations.

It follows from this description that the air in the tube is alternately rarefied and condensed. But these changes are very different in different parts of the tube. They must be greatest of all at A; because, while all the plates approach to A, they concur in condensing the air immediately adjoining to A; while the air in aa and $\alpha\alpha$ is less condensed by the action of the plates beyond it. The air at B is always of its natural density, being in equilibrio with the surrounding air. At B, therefore, there is a small parcel of air, of its natural density, which is alternately going in and out.

This account is confirmed by many facts. If the bottom of the pipe be shut by a fine membrane, stretched across it like a drumhead, with a wire stretched over it either externally or internally, in the same manner as the catgut is stretched across the bottom of a drum, it will be thrown into strong vibrations, making a very loud noise, by rattling against the cross wire. The same thing happens if the membrane be pasted over a hole close to the bottom, leaving a small space round the edge of the hole without paste, so that the membrane may play out and in, and rattle on the margin of the hole. This also makes a prodigious noise. Now, if the membrane be pasted on a hole far from the bottom, the agitations will be much fainter; and when the hole is near the mouth of the pipe, there will be none.—When a pipe has its air agitated in this manner, it is giving the lowest note of which it is susceptible.

Let us next consider a pipe open at both ends. Let CB (fig. 3.) be this pipe. It is plain that, if there be a partition A in the middle, we shall have two pipes AB, AC, each of which may undulate in the manner now described, if the undulations in each be in opposite directions. It is evidently possible, also, that these undulations may be the same in point of strength in both, and that they may begin in the same instant. In this case, the air on each side of the partition will be in the same state, whether of condensation or rarefaction, and the partition A itself will always be in equilibrio. It will perfectly resemble the point C of the musical cord BFCGH (fig. 6.), which is in equilibrio between the vibrating forces of its two parts. In the pipe, the plates of air on each side are either both approaching it, or both receding from it, and the partition is either equally squeezed from both sides, or equally drawn outwards. Consequently this partition may be removed, and the parcels of air on each side will, in any instant, support each other. There seems no other way of conceiving these vibrations in open pipes which will admit of an explanation by mechanical laws. The vibrations of all the plates must be obtained without any mutual hinderance, in order to produce the tone which we really hear; and therefore such vibrations are impressed by Nature on each plate of air.

But if this explanation be just, it is plain that this pipe CB must give the same note with the pipe AB (fig. 2.) of half the length, shut at one end. But the sound, being doubled, with perfect consonance, must be clear, strong, and mellow. Now this is perfectly agreeable to observation; and this fact is an unequivocal confirmation of the justness of the theory. If we take a slender pipe, about six inches long and one half of an inch wide, shut at one end, and sound it by blowing across its mouth, as we whistle on the pipe of a key, or across a hole that is close to the mouth, and formed with an edge like the sound-hole of a German flute, we shall get a very distinct and clear tone from it. If we now take a pipe of double the length, open at both ends, and blow across its mouth, we obtain the same note, but more clear and strong. And the note produced by blowing across the mouth is not changed by a hole made exactly in the middle, in respect of its musical

pitch

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pitch, although it is greatly hurt in point of clearness and strength. Also a membrane at this hole is strongly agitated. All this is in perfect conformity to this mechanism.

Thus we have, in a great measure, explained the effect of an open and a shut pipe. The shut pipe is always an octave, graver than an open pipe of the same length; because the open pipe is in unison with a shut pipe of half the length.

Let AC (fig. 4.) be a pipe shut at both ends. We may consider it as composed of two pipes AB, BC, stopped at A and C, and open at B. Undulations may be performed in each half, precisely as in the pipe AB of fig. 2.; and they will not, in the smallest degree, obstruct each other, if we only suppose that the plates in each half are vibrating at once in the *same* direction. The condensation in AB will correspond with the rarefaction in BC, and the middle parcel B will maintain its natural density, vibrating to, and again across the middle; and two plates *a a*, *α α*, which are equally distant from B, will make equal excursions in the same direction.

We may produce sound in this pipe by making an opening at B. Its note will be found to be the same with that of BC of fig. 2. or of AB of fig. 2.

In the next place, let a pipe, shut at one end, be considered as divided into any odd number of equal parts, and let them be taken in pairs, beginning at the stopped end, so that there may be an odd one left at the open end. It is plain that each of these pairs may be considered as a pipe stopped at both ends, as in fig. 4.

For the partitions will, of themselves, be in equilibrio, and may be removed, and vibrations may be maintained in the whole, consistent with the vibration of the odd part at the open end; and these vibrations will all support each other, and the plates of air which are at the points of division will remain at rest. Conceive the pipe AB of fig. 2. to be added to the pipe AC of fig. 4. the part A of the first being joined to A of the other. Now, suppose the vibrations to be performed in both, in such a manner that the simultaneous undulations on each side of the junction may be in opposite directions. It is plain that the partition will be in equilibrio, and may be removed; and the plate of air will perform the same office, being alternately the middle plate of a condensed and of a rarefied parcel of air. The two pipes CA, AB will together give the same note that AB would have given alone, but louder.

In like manner may another pipe, equal to AC, be joined to the shut end of this compound pipe, as in fig. 5. and the three will still give the same note that AB would have done alone.

And in the same manner may any number of pipes, each equal to AC, be added, and the whole will give still the same note that AB would have given alone.

Hence it legitimately follows, that if the undulations can be once begun in this manner in a pipe, it may give either the sound competent to it, as a single pipe AB (fig. 2.); or it may give the sound competent to a pipe of $\frac{1}{3}$d, $\frac{1}{5}$th, $\frac{1}{7}$th, &c. of its length; the undulations in each part AB, BC, CD, maintaining themselves in the manner already described. This seems the only way in which they can be preserved, both isochronous and synchronous.

It is known that the gravest tones of pipes are as the lengths of the pipes, or the frequency of the undulations are inversely as their lengths. (This will be *demonstrated* presently). Therefore these accessory tones should be as the odd numbers 3, 5, 7, &c. and the whole tones, including the fundamental, should form the progression of the odd numbers 1, 3, 5, 7, &c.

This is abundantly confirmed by experiment. Take a German flute, and stop all the finger holes. The flute, by gradually forcing the blast, will give the fundamental, the 12th, the 17th, the 21st, &c. (A).

Again, let AD (fig. 6.) represent the length of a pipe. Construct on AD an harmonic curve AEBFCGHD, in such a manner that HD may be $\frac{1}{2}$ AB, $= \frac{1}{2}$ BC, $= \frac{1}{2}$ CH. The small ordinates *m n* will express the total excursion of the plates of air at the points *m*, *m*, &c. and those ordinates which are above the axis will express excursions on one side of the place of rest, and the ordinates below will mark the excursions in the opposite directions, in the same manner as if this harmonic curve were really a vibrating cord. These excursions are nothing in the points A, B, C, H, and are greatest at the points E, F, G, D, where the little mass of air retains its natural density, and travels to and again, condensing the air at B, or rarefying it, according as the parcels E and F are approaching to or receding from each other. The points A, B, C, H, may be called Nodes, and the parts E, F, G, D, may be called Bights or Loops. This represents very well to the eye the motion of the plates of air. The density and velocity need not be minutely considered at present. It is enough that we see that when the density is increasing at A, by the approach of the parcel E, it is diminishing at B by the recess of E and F; and increasing at C, by the approach of F and G, and diminishing at H, by the recess of G. In the next vibration it will be diminishing at A and C, and increasing at B and H. And thus the alternate nodes will be in the same state, and the adjoining nodes in opposite states.

The reader must carefully distinguish this motion from

(A) A little reflection will teach us that these tones will not be perfectly in the scale. A certain proportion between the diameter and length of the pipe produces a certain tone. Making the pipe wider or smaller flattens or sharpens this tone a little, and also greatly changes its clearness. Organ-builders, who have tried every proportion, have adopted what they found best. This requires the diameter to be about $\frac{1}{10}$th or $\frac{1}{12}$th of the length. Therefore, when we cause the same pipe to sound different notes, we neglect this proportion; and the notes are false, and even very coarse, when we produce one corresponding to a very small portion of the pipe. For a similar reason, Mr Lambert found that, in order to make his pitch-pipe sound the octave to any of its notes, it was not sufficient to shorten its capacity one-half by pushing down the piston; he found that the part remaining must be less than the part taken off by a fixed quantity $1\frac{1}{5}$ inches. Or, the length which gave any note being *a*, the length for its octave must be $\frac{a - 1\frac{1}{5}}{2}$.

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from the undulatory motion of a pulse, investigated by Newton, and described in the article ACOUSTICS, *Encycl.* That undulation is going on at the same time, and is *a result* of what we are now considering, and the cause of our hearing this undulation. The undulation we are now considering is the original agitation, or rather it is the SOUNDING BODY, as much as a vibrating string or bell is; for it is not the trumpet that we hear, but the air trembling in the trumpet. The trumpet is performing the office, not of the string, but of the pin and bridge on which the string is strained. This is an important remark in the philosophy of musical sounds.

There is yet another set of notes producible from a pipe besides those which follow in the order of frequency 1, 3, 5, 7, &c.

Suppose a pipe open at both ends, sounding by blowing across the end, and undulating, as already described, with a node in the middle A (fig. 3.) If we still express the fundamental note of the pipe AB of fig. 2. by 1, it is plain that the fundamental of an open pipe of the same length will have the frequency of its undulations expressed by 2; because an open pipe of twice the length of AB (fig 2.) will be 1, the two pipes AB (fig. 2.), and CB (fig. 3), being in unison.

But this open pipe may be made to undulate in another manner; for we have seen that AC of fig. 2. joined to CA of fig. 4. may sound altogether when the partition A is removed, still giving the note of AB (fig. 2.) Let such another as AB (fig. 2.) be added to the end C, and let the partition be removed. The whole may still undulate, and still produce the same note; that is, a pipe open at both ends may sound a note which is the fundamental of a pipe like AB (fig. 2.), but only one-fourth of its length. The pipe CB of fig. 3. may thus be supposed to be divided into four equal parts, CE, EA, AF, FB, of which the extreme parts EC and FB contain undulations similar to those in AB (fig. 2.); and the two middle parts contain undulations like those in CA (fig. 4.) The partitions at E and F may be removed, because the undulations in EC and EA will support each other, if they are in opposite directions; and those in FB and FA may support each other in the same manner.

It must here be remarked, that in this state of undulation the direction of the agitations at the two extremities is the same; for in the middle piece EF the particles are moving one way, condensing the air at E, while they rarefy it at F. Therefore, while the middle parcel is moving from E towards F, the air at B must be moving towards F, and the air at C must be moving from E. In short, the air at the two extremities must, in every instant, be moving in the opposite direction to that of the air in the middle.

In like manner, if the pipe CB of fig. 3. be divided into six parts, the two extreme parts may undulate like AB of fig. 2. and the four inner parts may undulate like two pipes, such as CA of fig 4. and the whole will give the sound which makes the fundamental of a pipe of one sixth of the length, or having the frequency 6.

We may remark here, that the simultaneous motion of the air at the extremities is in opposite directions, whereas in the last case it was in the same direction. This is easily seen; for as the partition which is between the two middle pieces must always be in equilibrio, the air must be coming in or going out at the extremities together. This circumstance must give some sensible difference of character to the sounds 4 and 6. In the one, the agitations at each end of the tube are in the same direction, and in the other they are in the opposite. Both produce pulses of sound which are conveyed to the ear. Thus we see that the air in a pipe open at both ends may undulate in two ways. It may undulate with a node in the middle, giving the note of AB (fig. 2.), or of its 3d, 5th, 7th, &c. past; and it may undulate with a loop or bight in the middle, sounding like $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{6}$, &c of AB, fig. 2.

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In like manner may this pipe produce sounds whose frequency are expressed by 8, 10, &c. and proceed as the even numbers.

This state of agitation may be represented in the same way that we represented the sounds 1, 3, 5, &c. by constructing on AM (fig. 7.) an harmonic curve, with any number of nodes and loops. Divide the parts AF, FD, DE, EM, equally in C, O, P, B. CB will correspond to the pipe, and the ordinates to the curve GFHDLEN will express the excursions of the plates of air.

If the pipe gives its fundamental note, its length must be represented by CO, and the undulations in it will resemble the vibrations of part CO of a cord, whose length AD is equal to 2CO, and which has a node in F.

If the pipe is sounding its octave, it will be represented by CP, and its undulations will resemble the vibrations of a cord CP, whose length AE is $\frac{4}{3}$ of CP, having nodes at F and D, &c. &c.

We can now see the possibility of such undulations existing in a pipe as will be permanent, and produce all the variety of notes by a mere change in the manner of blowing, and why these notes are in the order of the natural numbers, precisely as we observe to happen in winding the trumpet or French horn. We have, *1st*, the fundamental expressed by 1; then the octave 2; then the 12th, 3; the double octave 4; then the third major of that octave 5, or 17th of the fundamental; then the octave of the 12th, or the 5th of this double octave, = 6. We then jump to the triple octave 8, without producing the intermediate sound corresponding to $\frac{1}{7}$th of the pipe. With much attention we can hit it; and it is a fact that a person void of musical ear stumbles on it as easily as on any other. But the musician, finding this sound begin with hum, and his ear being grated with it, perhaps thinks that he is mistaking his embouchure, and he slides into the octave. After the triple octave, we easily hit the sounds corresponding to $\frac{1}{9}$ and $\frac{1}{10}$, which are the 2d and 3d of this octave. The next note $\frac{1}{11}$ is sharper than a just 4th. We easily produce the note 12, which is a just 5th; 13 is a false 6th; 14 is a sound of no use in our music, but easily hit; 15 and 16 give the exact 7th and 8th of this octave.

Thus, as we ascend, we introduce more notes into every octave, till at last we can nearly complete a very high octave; but in order to do this with success, and tolerable readiness, we must take an instrument of a very low pitch, that we may be able nearly to fill up the steps of the octave in which our melody lies. Few players can make the French horn or trombone sound its real fundamental, and the octave is generally mistaken for it. The proof of this is, that most players can

give

give the 5th of the lowest note that they are able to produce; whereas the 5th of the real fundamental cannot be uttered. Therefore that lowest note is not the fundamental, but the octave to the fundamental.

Few performers can sound even this second octave on a short instrument, such as the ordinary military trumpet; and what they imagine to be the fundamental sound of this instrument is the double octave above it. This appears very strange; and it may be asked, how we know what is really the fundamental note of a trumpet? The answer to this is to be obtained only by demonstrating, on mechanical principles, what is the frequency of undulation corresponding to a given length of pipe. This is a proposition equally fundamental with its corresponding one in the theory of musical cords; but we have reserved it till now, because many readers would stop short at such an investigation, who are able to understand completely what we have now delivered concerning the music of the trumpet.

Suppose therefore a pipe shut at both ends, and that the whole weight of the contained air is concentrated in its middle point, the rest retaining its elasticity without inertia; or (which is a more accurate conception), let the middle point be conceived as extending its elasticity to the two extremities of the pipe, being repelled from each by a force inversely as the distance. Let the length of this pipe be L. This may also express the weight of the middle plate of air, which will always be proportional to the length of the pipe, because all is supposed to be concentrated there. Let E be the elasticity of the air. This must be measured by the pressure of the atmosphere, or by the weight of the column of mercury in the barometer. Perhaps the rationale of this will be better conceived by some readers by considering E as the height of a homogeneous atmosphere. Then it is plain that E is to L as the weight of this atmospheric column to the weight of the column of the same air which fills the pipe whose length is L. Then it is also plain that E is to L as the external pressure; and consequently, as the elasticity which supports that pressure is to the weight or inertia of the matter to be moved. Let this middle plate or diaphragm be withdrawn from its place of rest to the very small distance a. The elasticity or repulsion will be augmented on one side and diminished on the other; and the difference between them is the only force which impels the diaphragm toward the middle point, and causes it to vibrate, or produces the undulation. It is plain that the repulsion on one side is $\frac{\frac{1}{2}L}{\frac{1}{2}L-a}\times E$, or $\frac{L}{L-2a}E$ $\left(\text{for } \frac{1}{2}L-a:\frac{1}{2}L=E:\frac{\frac{1}{2}LE}{\frac{1}{2}L-a}\right)$, and the repulsion on the other side is $\frac{\frac{1}{2}L}{\frac{1}{2}L+a}\times E$, or $\frac{L}{L+2a}E$. The difference of these repulsions is $E\times L\times\frac{4a}{L^2-4a^2}$. But as we suppose a exceedingly small in comparison with L, this difference, or the accelerating force, may safely be expressed by $E\frac{4a}{L}$, or $4a\frac{E}{L}$.

Hence we deduce, in the first place, that the undulations will be isochronous, whether wide or narrow; because the accelerating force is always proportional to the distance a from the middle point.

Now, let a pendulum, whose quantity of matter is L, and length a, be supposed to vibrate in a cycloid by the force $\frac{4a}{L}E$, or $\frac{4E}{L}a$. It must perform its vibrations in the same time with the plate of air; because the moving force, the matter to be moved, and the space along which they are to be similarly impelled, are the same in both cases. Let another pendulum, having the same quantity of matter L, vibrate by its weight L alone. In order that these two pendulums may vibrate in equal times, their lengths must be as the accelerating forces. Therefore we must have $\frac{4E}{L}a:L=a:\frac{aL^2}{4Ea}, =\frac{L^2}{4E}$, which is therefore the length of the synchronous pendulum.

Now, a cord without weight and inertia, but loaded with the weight L at its middle point, and strained by a weight E, and drawn from the axis to the distance a, is precisely similar in its motion to the diaphragm we are now considering, and must make its oscillations in the same time.

This is applicable to any number of plates of air, by substituting in the cord a loaded point for each of the plates; for when the case is thus changed, both in the pipe and the cord, the space to be passed over by the plate of air bears the same proportion to a, which is passed over by the whole air concentrated in the middle point, which the space to be passed over by the corresponding loaded point of the cord bears to that passed over by the whole matter of the cord concentrated in the middle point; and the same equality of ratios obtains in the accelerating forces of the plate of air and the corresponding loaded point of the cord. Suppose, then, a pipe divided into 2, 3, 4, &c. equal parts, by 1, 2, 3, diaphragms, each of which contains the air of the intervening portion of the pipe, the whole weight L being equally divided among them. If there be but one diaphragm, its weight must be L; if two, the weight of each must be $\frac{1}{2}$ L; if three, the weight of each must be $\frac{1}{3}$ L; and so on for any number.

By considering this attentively, we may infer, without farther investigation, what will be the undulations of all the different plates of air in a pipe stopped at both ends. We have only to compare it with a cord similarly divided and loaded. Increase the number of loaded points, and diminish the load on each, continually—it is evident that this terminates in the case of a simple cord, with its matter uniformly diffused; and a simple pipe, with its air also uniformly diffused over its whole length.

Therefore, if we take an elastic cord, and stretch it by such a weight that the extending weight may bear the same proportion to the accelerating force acting on the whole matter concentrated in its middle point, which the elasticity of the air bears to its accelerating force acting on the whole matter concentrated at the mouth of an open pipe, sounding its fundamental note, the cord and the air will vibrate in the same time. Moreover, since the proportion between the vibrations of a cord so constituted, and those of a cord having its matter uniformly diffused, is the same with the proportion between the undulations in a pipe so constituted, and those of a pipe in which the air is uniformly diffused—it is plain that the vibrations of the cord and of the pipe

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pipe in their natural state will also be performed in equal times.

We look on this as the easiest way of obtaining a distinct perception of the authority on which we rest our knowledge of the absolute number of undulations of the air in a pipe of given length. It may be obtained directly; and Daniel Bernoulli, Euler, and others, have given very elegant solutions of this problem, without having recourse to the analogy of the vibrations of cords and undulations of a column of air. But it requires more mathematical knowledge than many readers are possessed of who are fully able to follow out this analogical investigation.

Let us therefore compare this theory with experiment. What we call an open pipe of an organ is the same which we, in this theory, have considered as a pipe open at both ends; for the opening at the foot, which the organ-builders call the VOICE of the pipe, is equivalent to a complete opening. The aperture, and the sharp edge which divides the wind, may be continued all round, and the wind admitted by a circular slit, as is represented in fig. 10 We have tried this, and it gives the most brilliant and clear tones we ever heard, far exceeding the tones of the organ. An open organ pipe, therefore, when sounding its fundamental note, undulates with one node in its middle, and its undulations are analogous, in respect of their mechanism, with the vibrations of a wire of the same length, and the same weight, with the column of air in the pipe, and stretched by a weight equal to that of a column of the same air, reaching to the top of a homogeneous atmosphere, or equal to the weight of a column of mercury as high as that in the barometer

Dr Smith (see *Harmonics*, 2d edit. p. 193) found that a brass wire, whose length was 35,55 inches, and weight 31 troy grains, and stretched by 7 pounds avoirdupois, or 49000 grains, was in perfect unison with an open organ pipe whose length was 86,4 inches.

Now 86,4 inches of this wire weighs 75,34 grains. When the barometer stands at 30 inches, and the thermometer at 55° (the temperature at the time of the experiment), the height of a homogeneous atmosphere is 332640 inches. This has the same proportion to the length of the pipe which the pressure of the atmosphere has to the weight of the column of air contained in the pipe.

Now $86,4 : 332640 = 75,34 : 290060$. This wire, therefore, should be stretched (if the theory be just) by 290060 grains, in order to be unison with the other wire, and we should have $35,55^2 : 86,4^2 = 49000 : 290060$
But, in truth, - $35,55^2 : 86,4^2 = 49000 : 289430$
The difference is - - - - - - 630
The error scarcely exceeds $\frac{1}{500}$, and does not amount to an error of one vibration in a second.

We must therefore account this theory as accurate, seeing that it agrees with experiment with all desirable exactness.

We may also deduce from it a very compendious rule for determining the absolute number of aereal pulses made by an open pipe of any given length. When considering the vibrations of cords, we found that the number of vibrations made in a second is $\sqrt{\frac{386E}{LW}}$, where E is the extending weight, W the weight of the cord, and L its length. Let H be the height of a homogeneous atmosphere. We have its weight $= \frac{HW}{L}, = E$. Therefore substituting $\frac{HW}{L}$ for E in the above formula, we have the number of aereal pulses made per second $= \sqrt{\frac{386H}{L^2}}$, or $= \frac{\sqrt{386H}}{L}$. Now $\sqrt{386H}$, computed in inches, is 11331. Therefore, if we also measure the length of the pipe L in inches, the pulses in a second are $= \frac{11331}{L}$. Thus, in the case before us, $\frac{11331}{86,4} = 131,12$, or this pipe produces 131 pulses in a second. Dr Smith found by experiment that it produced 130,9, differing only about $\frac{1}{5}$th of a pulse.

We see that the pitch of a pipe depends on the height of the homogeneous atmosphere. This may vary by a change of temperature. When the air is warmer it expands, and the weight of the induced column is lessened, while it still carries the same pressure. Therefore the pitch must rise. Dr Smith found his organ a full quarter tone higher in summer than in winter. The effect of this is often felt in concerts of wind instruments with stringed instruments. The heat which sharpens the tone of the first flattens the last. The harpsichord soon gets out of tune with the horns and flutes.

Sir Isaac Newton, comparing the velocity of sound with the number of pulses made by a pipe of given length, observed that the length of a pulse was twice the length of the open pipe which produced it. Divide the space passed over in a second by the number of pulses, and we obtain the length of each pulse. Now it was found that a pipe of 21,9 inches produced 262 pulses. The velocity of sound (as computed by the theory on which our investigation of the undulations in pipes proceeds) is 960 feet. Now $\frac{960\times12}{262}=44$ inches very nearly, the half of which is 22, which hardly differs from 21,9. The difference of this theoretical velocity of sound, and its real velocity 1142 feet per second, remains still to be accounted for. We may just observe here, that when a pipe is measured, and its length called 21,9, we do really allow it too little. The voice hole is equivalent to a portion, not inconsiderable of its length, as appears very clearly from the experiments of Mr Lambert on a variable pitch pipe, and on the German flute, recorded in the Berlin Memoirs for 1775. He found it equivalent to $\frac{1}{6}$th; and this is sufficient for reconciling these measures of a pulse with the real velocity of sound.

The determination which we have given of the undulations of air in an organ pipe is indirect, and is but a sketch of the beautiful theory of Daniel Bernoulli, in which he states with accuracy the precise undulation of each plate of air, both in respect of position, density, velocity, and direction of its motion. It is a pleasure to observe how the different equations coincide with those which express the vibrations of an elastic cord. But this would have taken up much room, and would not have been suited to the information of many curious readers, who can easily follow the train of reasoning which we have employed.

Mr Bernoulli applies the same theory to the explanation

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nation of the undulations in flutes, or instruments whose sounds are modified by holes in the sides of the pipe. But this is foreign to our purpose of explaining the music of the trumpet. We shall only observe, that a hole made in that part of a pipe where a node should form itself, in order to render practicable the undulations competent to a particular note, prevents its formation, and in its place we only get such undulations (and their corresponding sounds) as have a loop in that place. The intelligent reader will perceive that this single circumstance will explain almost every phenomenon of flutes with holes; and also the effects of holes in instruments with a reed voice, such as the hautboy or clarionette.

We now see that the sound or musical pitch of a pipe is inversely as its length, in the same manner as in strings. And we learn, by comparing them, that the sound of a trumpet has the same pitch with an open organ pipe of the same length. A French horn, 16 feet long, has the sound C *fa ut*, which is also the sound of an open flute-pipe of that length.

The TROMBONE, great trumpet, or SACKBUT, is an old instrument described by Mersennus and other authors of the last century. It has a part which slides (air-tight) within the other. By this contrivance the pitch can be altered by the performer as he plays. This is a great improvement when in good hands; because we can thus correct all the false notes of the trumpet, which are very offensive, when they occur in an emphatical or holding note of a piece of music. We can even employ this contrivance for filling up the blanks in the lower octaves.

We must not take leave of this subject without taking notice of another discovery of Mr Bernoulli's, which is exceedingly curious, and of the greatest importance in the philosophy of music.

Artists had long ago observed that the deep notes of musical instruments are sometimes accompanied by their harmonic sounds. This is most clearly perceived in bells, some of which give these harmonics, particularly the 12th, almost as strong as the fundamental. Musicians, by attending more carefully to the thing, seem now to think that this accompaniment is universal. If one of the finest sounding strings of the bases of a harpsichord be struck, we can hear the 12th very plainly as the sound is dying away, and the 17th major is the last sound that dies away on the ear. This will be rendered much more sensible, if we divide the wire into five parts, and at the points of division tie round it a thread with a fast knot, and cut the ends off very short. This makes the string false indeed by the unequal loading; but, by rendering those parts somewhat less moveable by this additional matter, the portions of the wire between these points are thus jogged, as it were, into secondary vibrations, which have a more sensible proportion to the fundamental vibration. This is still more sensible in the sound of the strings of a violincello when so loaded; but we must be careful not to load them too much, because this would so much retard the fundamental vibration, without retarding the secondary vibrations, that both cannot be maintained together. (*N. B.* This experiment always produces a beat in the sound).—Listening to a fine sounding flute pipe of the organ, we can also very often perceive the same thing. Mr Rameau, and most other theorists in music, now assert that this is the essence of a musical sound, and *necessarily* exists in all of them, distinguishing them from harsh noises. Rameau has made this the foundation of his system of music, asserting that the pleasure of harmony results from the successful imitation of this harmony of Nature, (see MUSIC, *Encycl.*). But a little logic should convince these theorists that they must be mistaken. If a note is musical because it has these accompaniments, and by this composition alone is a musical note, what are these harmonics? Are they musical notes? This is granted. Therefore they have the same composition; and a musical note must consist at once of every possible sound; yet we know that this would be a jarring noise. A little mathematics, too, or mechanics, would have convinced them. A simple vibration is surely a most possible thing, and therefore a simple sound. No, say the theorists; for though the vibration of the cord may be simple, it produces such undulations in the air as excite in us the perception of the harmonics. But this is a mere assertion, and leaves the question undecided. Is not a simple undulation of the air as possible as the simple vibration of a cord?

It is, however, a very curious thing, that almost all musical sounds really have this accompaniment of the octave, 12th, double octave, and 17th major; for these are the harmonics that we hear.

The jealousy of Leibnitz and of John Bernoulli, and their unfriendly thoughts respecting all the British mathematicians, made John Bernoulli do every thing in his power to lessen the value of Dr Taylor's investigation of the vibration of a musical cord. Taylor gave him a good opportunity. Perhaps a little vain of his investigation of this abstruse matter, he thought too much of it. He affirmed that the harmonic curve was the essential form of a string giving a musical note. This was denied, without knowing at first whether it was true or false. But as the analytic mathematics improved, it was at length found that there are an infinity of forms into which an elastic cord can be thrown, which are consistent both with isochronous vibrations, whether wide or narrow, and also with the condition of the whole cord becoming a straight line at once. Euler, D'Alembert, and De la Grange, have prosecuted this matter with great ingenuity, and it is one of the finest problems of the present day.

Daniel Bernoulli, of a very different cast of mind from his illustrious friends, admired both Newton and Taylor; and so far from wishing to eclipse Dr Taylor by the additions he had made to his theory, tried whether he could not extend Taylor's doctrine as far as the author had said. When he took a review of what he had done while explaining the partial vibrations of musical cords, he thought it very possible that while a cord is vibrating in three portions, with two nodes or points of rest, and sounding the 12th to its fundamental, it might at the same time be also vibrating as a simple cord, and sounding its fundamental note. It was possible, he thought, that the three portions might be vibrating between the four points with a triple frequency, while the two middle nodes were vibrating across the straight line between the two pins; and thus the vibrating cord might be a moveable axis, to which the rapid vibrations of the three parts might always be referred. This was very specious; and when a little more attentively considered, became more probable: for if the

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the cord $ApBqCrD$ (fig. 8.) be vibrating as a 12th to its fundamental AD, the points B and C are in equilibrio. If therefore these two points be laid hold of by hooks, and be drawn aside to β and γ, while the string is yet vibrating, this should not hinder the vibrations. If the hooks be annihilated in an instant, the whole should vibrate between A and D; and this should be in a way very different from the simple vibration. The question now is, will the cord *continue* to vibrate with the loops $\beta s \gamma$, $\beta q \gamma$, &c. in the 900th part of a second (for instance), while the whole string vibrates from $A\beta\gamma D$ to $A\beta'\gamma'D$ in the 300th part of a second? or will it at once acquire the form of the simple harmonic curve? The case in which it is most likely to take the latter mode of vibration is when the points β and γ are let go at the instant that each portion of the string is in the middle of its vibration, and therefore forms the line $A\beta\gamma D$. But a moment's consideration will shew us that it cannot do this; for at that instant the point v, for instance, which had come from q, is moving outwards with a most rapid motion, and therefore will continue to go outward, while β and γ are approaching the axis. The point w, on the contrary, is at this moment approaching the axis with a motion equally rapid. They cannot therefore all come to the axis at once, and the vibration must differ greatly from a simple one. On the other hand, let it be supposed that both species of vibrations can be preserved, and that, at the moment of letting go the points β and γ, the cord has the form $Am\beta q\gamma nD$. Then, when β and γ have come to B and C, having made $\frac{1}{4}$ a vibration, the point m will be in the axis, having made a vibration downward, and a half vibration upwards. q, in like manner, is in the axis, having made a whole vibration upwards, and half a vibration downwards. n is like m. Thus the whole comes to the axis at once; and in such a manner, that if the points B and C were instantly stopped, the three portions would continue their partial vibrations without any new effort. The result of this compound vibration must be a compound pulse of air, which will excite in us the perception of the fundamental sound and of its 12th. The consequence will be the same if the points β and γ are stopped any where short of the axis; and therefore (said Bernoulli) the string will really vibrate so if not stopped at all.

But this was refused by Euler, who observed that in the points β and γ of contrary flexure, having no curvature, there can be no accelerating force. This caused Bernoulli to attempt a direct investigation, examining minutely the curvatures and accelerating forces in the different points.

He had the pleasure of finding that the accelerating forces arising from the curvature in every point, were precisely such as would produce the accelerations necessary in those points for performing the motion that was required. And he exhibited the equations expressive of the state of the cord in all these points. And, on the faith of these equations, he restored the Taylorean curve to the rank which its inventor had given it; and he asserted that in every musical vibration the cord was disposed in a harmonical curve either simple or compound. He farther shewed that the equations which Euler and D'Alembert had given for the musical cord (at least in the cases which they had published) were included in his equations, and that their equations only exhibited its momentary states, while his own equations shewed the physical connection of them all; which is, that the whole cord forms a harmonic curve between the two fixed pins, while its different portions form subordinate harmonic curves on the first as an axis. Euler and D'Alembert, although they acknowledge this in the particular cases which they had taken as examples, on account of their simplicity, still insist that no subordinate harmonic vibrations can correspond to all the states of an elastic cord which their equations exhibit as isochronous and permanent. Mr Bernoulli's death put an end to the controversy, and the question (considered as a general theory) is perhaps still undecided. It may very probably be true, that as a simple vibration may be permanent which never has the form of the simple harmonic described by Dr Taylor, so a vibration may exist compounded of such vibrations, and therefore not expressible by any equation deduced from the Taylorean curve.

But, in the mean time, Mr Bernoulli has made the most beautiful discovery in mechanics which has appeared in the course of the present century, and has explained the most curious phenomenon of continued sounds, *viz.* the *almost universal* accompaniment of the harmonic notes of any fundamental sound. For this *susceptibility* of compounded variation is not confined to a 12th, but is equally demonstrable of every other harmonic. Nay, it is evident that the same simple vibration of a cord may furnish a moveable axis to more than one harmonic. For as the simple vibration can have a subordinate harmonic vibration superinduced upon it, so may this compounded vibration have another superinduced on it, and so on to any degree of composition. And farther, as Mr Bernoulli has shewn the complete analogy between the accelerations of the different points of an elastic cord and of the corresponding plates of a column of air, it legitimately follows that all the consequences which we can easily deduce, respecting the vibrations of an elastic cord, may be affirmed respecting the undulations of a column of air in a pipe. Therefore this accompaniment of the harmonics must not be confined to the music of strings and bells, but equally obtains in the music of wind instruments. And thus the doctrine becomes universal.

Mr Bernoulli did not think it enough to shew that these compound vibrations are possible. He endeavours to shew that this accompaniment must be frequent. He illustrates this very prettily, by supposing that a toothed wheel is turned round, and rubs with its teeth on an elastic cord. If the successive dropping of the teeth keep exactly pace with such vibrations as the cord can take and maintain by its elasticity, these will certainly be formed on it. If the intervals do not *exactly* correspond, a little reflection will shew that the agitation which the cord acquires will approximate to those which it can maintain; and, if when they are exactly so in any place of it, and the wheel be in that instant removed, this vibration will remain and diffuse itself throught he rest of the cord; so that the very last dying quiver (so to speak) will be a harmonic. Every *harmonic* agitation tends, by the very nature of the thing, to continue, while those that are incompatible really *do* destroy each other; and the very last must be the remainder or superplus of such as could continue,

over

Fig. 1.

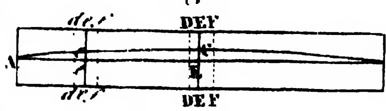


Fig. 2.

Fig. 3.

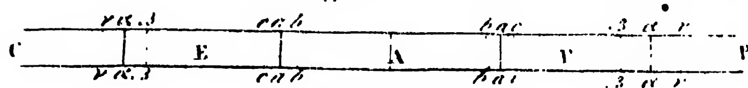


Fig. 4.

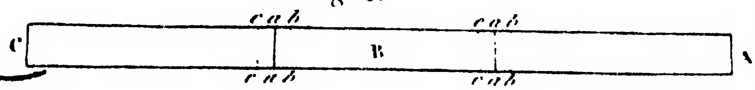


Fig. 5.

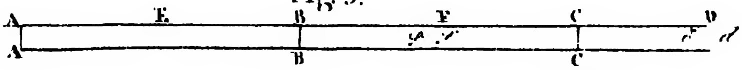


Fig. 6.

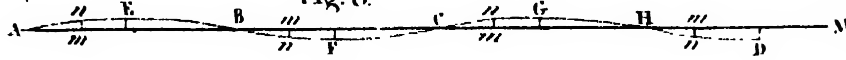


Fig. 7.

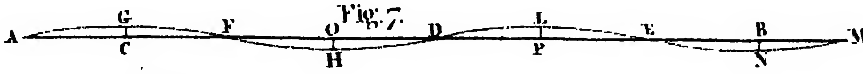


Fig. 8.

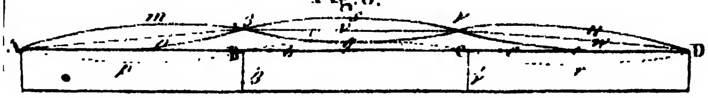


Fig. 9.

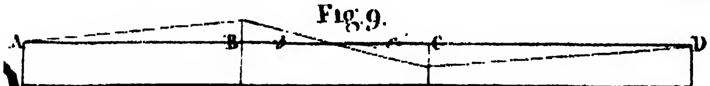


Fig. 10.

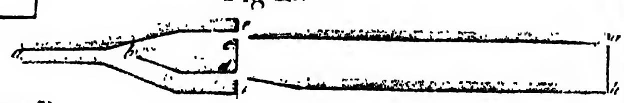
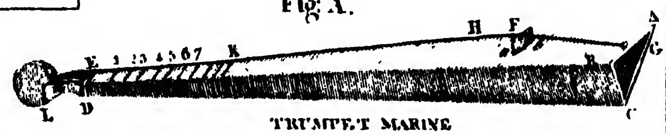


Fig. A.



TRUMPET MARINE

Fig. C.

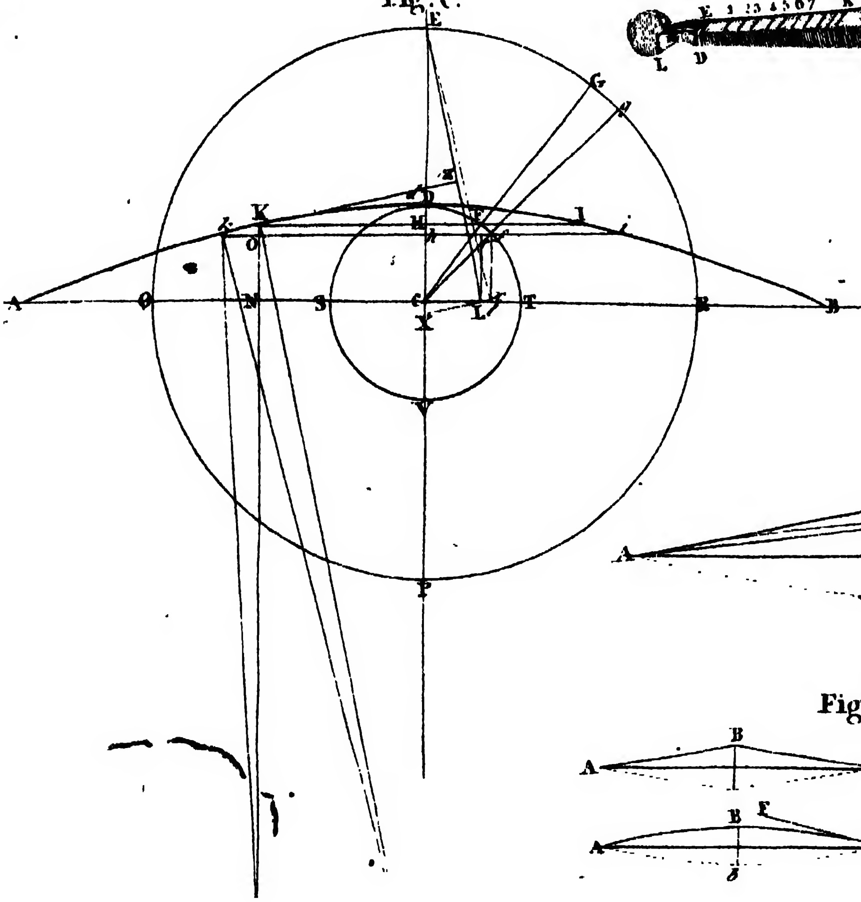


Fig. B.

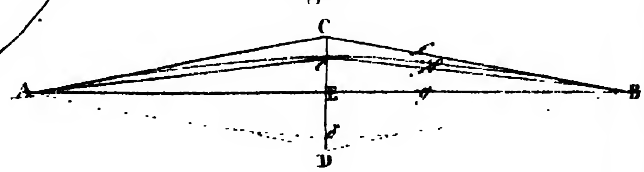
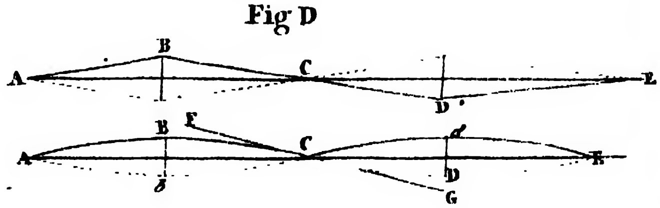


Fig. D



Musical Trumpet.

over those which destroyed each other. Accordingly, the harmonic notes of wires are always most distinctly heard as the sound is dying away.

There is no occasion now to say any thing about the fallacy of Rameau's *Generation Harmonique* as a theory of musical pleasure. Our harmonies please us, not because a sound is accompanied by its harmonics, but because harmonics please. His principle is therefore a tautology, and gives no instruction whatever. His theory is a very *forced* accommodation of this principle to the practice of musicians, and taste of the Public. He is exceedingly puzzled in the case of the *sousdominante*, or 4th of the scale, and the 6th where there is no resonance. He says that these notes, "fremissent, quoiqu' elles ne resonnent pas." But this misleads us. They do not resound; because a 4th and a 6th cannot be produced at all by dividing the cord. They tremble; because the false 4th and false 6th are very near the true ones, and the true 4th and 6th would both tremble and resound, if they were made false. A string will both tremble and resound, if very nearly true, as any one observes the 12th and 17th on a harpsichord tremble and resound very strongly, though they are tempered notes. The whole theory is overturned at once by tuning the 4th false, so as to correspond to an aliquot division of the cord. It will then resound; and it this had happened to be agreeable, it would have been catched at as the sousdominant.

The physical cause of the pleasure of harmonic sounds is yet to seek, as much as our choice of those notes for melody which give us the best harmony (see TEMPERAMENT, *Suppl.*). We have no hesitation in saying that, with respect to our choice, the two are quite independent. Thousands enjoy the highest pleasure from melody who never heard a harmonious sound. All the untaught singers, and all simple nations, are examples. They not only fix on certain intervals as the steps of their tunes, but are disgusted when other steps are taken. Nor do we hesitate, for the very same reasons, to say that the rules of accompaniment are dependent on the cantus or air, and by no means on the fundamental bass of Rameau. The dependence assumed by him, as the rule of accompaniment, would, if properly adhered to, according to his own notions of the comparative values of the harmonics, lead to the most fantastic airs imaginable, always jumping by large intervals, and altogether incompatible with graceful music. The rules of modulation which he has squeezed out of his principle, are nothing but forced, very forced, accommodations of a very vague principle to the current practice of his contemporaries. They do not suit the primitive melodies of many nations; and they have caused these national musics to degenerate. This is acknowledged by all who are not perverted by the prevailing habits. We have heard, and could write down, some most enchanting lullabies of simple peasant women, possessed of musical sensibility, but far removed, in the cool sequestered vale of life, from all opportunities of stealing from our great composers. Some of these lullabies never fail to charm, even the most erudite musician, when sung by a fine flexible voice: but it would puzzle Mr Rameau to accompany them *secundum artem*.

We conclude this subject by describing a most beautiful and instructive experiment.

Mr Watt, the celebrated engineer, was amusing himself (about the year 1765) with organ building, and invented a monochord of continued sound, by which he could tune an organ with mathematical precision, according to any proposed system of temperament. It consisted of a covered string of a violincello, sounding by the friction of an ivory wheel. The instrument did not answer Mr Watt's purpose, by reason of the dead harshness of its tone, and a flutter in the string by the unequal action of the wheel. But Mr Watt was amused by observing the string frequently taking, of its own accord, points of division, which remained fixed, while the rest was in a state of strong vibration. The instrument came into the possession of the writer of this article. He soon saw that it gave him an opportunity of making all the experiments which Bernoulli could only relate. When the string was kept in a state of simple vibration, by a very uniform and gentle motion of the wheel, if its middle point was then gently touched with a quill, this point immediately stopped, but the string continued to vibrate in two parts, sounding the octave: And this it continued to do, however strong the vibrations were rendered afterwards by increasing the pressure and velocity of the wheel. The same thing happened if the string was gently touched at one third. It instantly divided itself into three parts, with two nodes, and sounded the 12th. In the same manner the double octave, the 17th, and all other harmonics, were produced and maintained.

But the prettiest experiment was to put something soft, such as a lock of cotton, in the way of the wide vibrations of the cord, at one third and two-thirds of its length, so as to disturb them when they became very wide. When this was done, the string instantly put on the appearance of fig. 8. performing at once the full vibration competent to its whole length, and the three subordinate vibrations, corresponding to one-third of its length, and sounding the fundamental and the 12th with equal strength. In this manner all the different accompaniments were produced at pleasure, and could be continued, even with strong sounds. And it was amusing to observe, when the wheel was strongly pressed to the string, and the motion violent, the nodes would form themselves on various parts of the string, running from one part to another. This was always accompanied with all the jarring sounds which corresponded to them.

When the string was making very gentle, simple vibrations, and the wheel hardly touching it, if a violincello was made to sound the 12th very strongly in its neighbourhood, the string instantly divided itself, and vibrated in unison, frequently retaining its simple vibration and fundamental tone. We recommend this experiment to every person who wishes to make himself well acquainted with the mechanism of musical sounds. He will see, in a most sensible and convincing manner, how a single string of the Æolian harp gives us all the changes of harmony, sliding from one sound to another, according as it is affected in its different parts by an irregular breeze of wind. The writer of this article has attempted to regulate these sweet harmonic notes, and to introduce them into the organ. His success has been very encouraging, and the sounds far exceed in pathetic sweetness any that have yet been produced by that noble instrument. But he has not yet brought them fully under command, nor made them strong enough for any thing but the softest chamber music. Other

necessary occupations prevent him from giving the attention to this subject that it deserves. He recommends it therefore to the musical instrument makers as richly deserving their notice. His general method was this: A wooden pipe is made, whose section is a double square. A partition in the middle divides it into two pipes, along side of each other. One of them communicates with the foot and wind chest, and is shut at the upper end. The other is open at the upper, and shut at the lower end. In the partition there is a slit almost the whole length, and the sides of this slit are brought to a very smooth chamfered or feather edge. A fine catgut is strained in this slit, so as almost to touch the sides. It is evident that when the wind enters one pipe by the foot, it passes through the slit into the other, and escapes at the top, which is open. In its passage it forces the catgut into motion, and produces a musical note, having all the sweetness of the Æolian harp. The strength of sound may be increased by increasing the body of air which is made to undulate. This was done by using, instead of catgut, very narrow silk tape or ribband varnished: but the unavoidable raggedness of the edges made the sounds coarse and wheezing. Flat silver wire was not sufficiently elastic; flat wire, used for watch balance springs, was better, but still very weak sounded. Other methods were tried, which promised better. A thin round plate of metal, properly supported by a spring, was set in a round hole, made in another plate not so thin, so as just not to touch the sides. The air forced through this hole made the spring plate tremble, dancing in and out, and produced a very bold and mellow sound.—This, and similar experiments, are richly worth attention, and promise great additions to our instrumental music.

TSCHIRNHAUS (Ehrenfried Walther Von), a name well known in the republic of letters, and one of the ornaments of the last century, was born April 10. 1651, at Kislingswald near Gorlitz in Upper Lusatia. His father was Ernest Christopher Von Tschirnhaus, Baron Kislingswald and Stoltzberg, and Obernschonfeld, privy counsellor, and in various offices of rank under the Electors George I. and II. of Saxony, the first of whom honoured him with the distinction of the gold chain and portrait, as a mark of his sense of his merits and services. The mother of the young Von Tschirnhaus was Maria Stirling, daughter of *Baro a Stirling et Achil*, Stirling of Achil, or Achyle, in Scotland, an old and respectable family, as appears by an epitaph which the Duke Christian, brother of the Elector George II. inscribed on the tomb of Johan Albert Stirling of Achil, in the cathedral of Marckspurg. This gentleman had been president of the senate of the electorate, privy counsellor, director of the imposts, and master of horse to the Prince, and had, by his faithful and useful services, acquired his highest esteem.

E. W. Von Tschirnhaus was born, as has been observed, at Kislingswald, the usual residence of the family, and possessed by it during more than 300 years. The family came originally from Bohemia, and appears to have been considerable, seeing that, from the earliest accounts of it in Lusatia, the Barons of Kislingswald are generally found in the most respectable civil offices.

The figure which Baron Von Tschirnhaus, the subject of this relation, has made in the scientific and political world, makes it superfluous to say that his early years were well employed. Quick apprehension, a clear perception of the subject of his thoughts, and the most ardent and insatiable thirst for knowledge, distinguished him during his academical education. When 17 years of age, he was sent to Leyden. In 1672 all study was interrupted in Holland by the din of war; and Mr Von Tschirnhaus left the university for the camp. His knowledge in mathematics, mechanics, and all physical science, found ample room in the military service for shewing the importance of those sciences; and Tschirnhaus so distinguished himself by his service in this way, that Baron Nieuland, a general officer of great merit, and at the same time an accomplished scholar, took delight in pushing him into every service where he could shew himself and his talents.

Tschirnhaus.

After two years service, he returned to his father's; but finding little to interest him in the life of a mere country gentleman, and still burning with the same thirst of knowledge, he prevailed on his father to allow him to travel. His younger brother George Albrecht Von Tschirnhaus, Baron Oberschonfeld, which he inherited from his grandfather Stirling, loved him with the warmest affection, and supplied him liberally with what was required for his appearance everywhere in a manner becoming his rank, and for fully gratifying his curiosity. He used often to say, "Sorry was I to lose the company of my dear brother, and I sometimes wished to accompany him; but not having his thirst for knowledge, I knew that his love for me would debar him of much happiness, which I should thus have obstructed." *Felices animæ!* He went to Holland, from thence into England, France, Italy, Sicily, Malta, Greece.—Returning through the Tyrol, he met his brother at Vienna, where both were in great favour at the court of Leopold Wherever he went, he made himself acquainted with the most eminent in all departments of science, living with them all in the mutual exchange of discoveries and of kind offices. In Holland he was intimate with Huyghens and Hudde; in England, with Newton, Wallis, Hailey, and Oldenburgh; in France, among a people who more speedily contract acquaintance, there was not a man of note with whom he did not cultivate an active acquaintance—and, fortunately, Leibnitz then lived at Paris: in Italy, he was particular caressed by Michaeli, soon after Cardinal; and was in the closest correspondence with Kircher. His enjoyments, however, were derived solely from the communications of the most eminent; his curiosity was directed to every thing, and wherever he saw an ingenious artisan, he was eager to learn from him something useful. In 1682, when at Paris for the third time, he communicated to his friends his celebrated theory of the caustic curves, which marked him out as a valuable acquisition, and he was elected a member of the Royal Academy of Sciences, which was then reformed by the great minister Colbert, and the most illustrious in all nations were picked out for its ornaments. There he found himself seated with Leibnitz, Huyghens, John Bernoulli, &c.

After twelve years employed in visiting Europe, he returned home: but after a short stay, went to Flanders, and prepared to publish his work, intitled *Medicina Mentis*; of which the subject may almost be guessed, from the way in which he had exercised his own mind. Having the most exalted notions of the intellectual and moral

moral nature of man, he thought that the continual supply of information was as necessary as the continual supply of food. And his great principle was TO ENLIGHTEN. This work was committed to the care of some friends, and did not appear till 1687, at Amsterdam. A second edition appeared at Leipsic in 1695.

Finding now that his moderate fortune was insufficient for the great public projects he had in view, he sought for assistance, and endeavoured to make friends by frequenting the court of the Elector at Dresden. He soon became a favourite of his Princes, George the II. and III. and was appointed to active offices of great responsibility. By the orders and encouragement of the Elector, then king of Poland, he introduced into his native country the first manufacture of glass; and his project soon throve to such a degree, that not only Saxony was supplied, but they even began to export the finer kinds of white glass for windows; in which manufacture Saxony still excels. It was in the course of experiments for improving this manufacture that Tschirnhaus made the celebrated great burning glasses which still bear his name. He made two of these lenses, and gave one to the Emperor, and the other to the Academy of Paris. He was eager to improve the art of forming and polishing optical glasses; and in the prosecution of the theory on which their performance depends, he made some beautiful discoveries in the department of pure geometry. It is well known that all the sciences are allied, and of a family, and that eminence in one is seldom attainable without the assistance of others. His present pursuits led him to the study of chemistry, which he prosecuted with the same ardour which he exhibited in every thing he undertook. But all the while, mathematics, and especially geometry, was his favourite study; and he was anxious to make the same advances in the general paths of mathematical investigation which he thought he had made in the general laws of material nature. He apprehended that only bye paths were yet known, and that many things were yet inaccessible; because we had not yet found out the great roads from which those branches were derived. He was of Des Cartes's opinion, that the true road in mathematics must be an easy one, except in cases which were, in their own nature, complicated. Very early, therefore, he began writing on mathematical subjects, always continuing his general views of the science, and his endeavours to systematise the study; but, at the same time, bestowing a very particular attention on any branch which chanced to interest him; each of these his episodical studies in mathematics deserves the name of a department of the science. This is the case with his theory of caustic curves, with his method of tangents, and his attempt to free Leibnitz's calculus from all consideration of infinitesimal quantities. Mr Tschirnhaus seldom gave himself any trouble with a particular problem. In all his mathematical performances, there is an evident connection with something which he considered as the great whole of the science; and the manner of treating the different questions is plainly accommodated to a system in his thoughts. This he intended as the third part of the Medicina Mentis; and, having nearly completed the second, he had proposed these as the occupation of the ensuing winter (1708-9). But his death, which may be called premature, has deprived the world of these, and other beneficent and useful labours.

Tschirnhaus.

Mr Von Tschirnhaus was of the most mild and gentle disposition, as was well known to all who enjoyed his acquaintance. This disposition was so eminent in him, that scarcely any person ever saw him angry, or even much ruffled in his temper. He forgave injuries frankly and heartily, and often stood the friend (unknown) of those who had wronged him. By such conduct, he changed some enmities into the most steady and affectionate friendships. As an inquirer and an inventor, he had contentions with other claimants, and some disputes about the legitimacy of his methods; as, for example, with Nicholas Fatio Duiller, who attacked Tschirnhaus's method of tangents; and Prestet and Rolle, who found fault with his expression of equations of the third degree. But these were all friendly debates, and never carried him beyond the limits of gentlemanly behaviour. He began to dispute with Ozanam about a quadratrix; but on being merely told that he was mistaken, by P. Souciet, he immediately acknowledged his error, and corrected it.

Many original and important mathematical performances of Mr Von Tschirnhaus are to be seen in the Leipsic Acts, in the Memoirs of the Academy of Sciences at Paris, and other literary journals. His happy generalisation of Dr Barrow's theorem for the focus of a slender pencil of rays after reflection or refraction, and the theory of caustic curves, in which this terminates, both constitutes one of the most elegant branches of optical science, and affords a rich harvest of very curious and unexpected geometrical truths. The manner in which he notices the rough way in which his first and sole mistake in this theory was pointed out, is perhaps incomparable as an example of gentlemanlike reprehension, and is a lesson for literati of all descriptions, highly valuable on account of the soft way in which it falls, while it is convincing as a mathematical theorem.

Tschirnhaus was the discoverer of the substance of which the celebrated Saxon porcelain is made, and of the manner of working it up; by which he established a manufacture highly profitable to his country, and has given us the finest pottery in the world. He never wearied in spreading useful knowledge; and the shops of our artisans of almost all kinds were supplied with books of instructions and patterns, many of them written by Mr Von Tschirnhaus, or under his inspection. Useful books of all kinds were translated out of foreign languages at his expence. Men of genius in the arts were enabled, through the encouragement of himself and his friends, and often by his pecuniary assistance, to bring their talents before the public eye. In short, he seemed at all times to prefer the public good to his own; and never felt so much pleasure as when he could promote science or the useful arts. He was as it were stimulated to this by an innate propensity. And as he was more desirous of *being* than of *appearing* the accomplished man, he was in no concern what notice others took of his services to the public. He even represents the desire of fame as hostile to the improvement either of science or morality, in his *Medicina Mentis*; a work which is acknowledged by all who knew him to be a picture of his own amiable mind. He lightly esteemed riches; and knew not what

use

Tschirnhaus. use they were of, except for providing the necessaries of life, and the means of acquiring knowledge. In perfect conformity to this maxim, he modestly, and with elegant respect, refused the ample presents made him by his affectionate sovereign; and when he was added to his cabinet council, he received the diploma, but begged and obtained to be free from the title. And when he presented his great burning glass to the Emperor, and got from him the dignity and insignia of Baron of the Empire, he pleaded for leave to decline it, requesting to keep the chain and portrait, which he always wore under his vest. He expended a very great portion of the ample revenue left him by his father in the service of his country, by promoting the useful arts and sciences.

Mr Von Tschirnhaus venerated truth above all things; saying, that those who thought any thing comparable with it were not the sons of God. but step-children, and that the love of truth is the ruling affection in every man of a worthy heart. In a letter to an intimate friend, he said that, by the age of five-and-twenty, he had completely subdued the love of glory, of riches, and of worldly pleasures; and that at no time he had found it difficult to repress vanity, because he was every day conscious of having acted worse than he was certain that he might and should have done. He felt himself humbled in the sight of the All perfect Judge.

Nor was all this the vain boast of a man averse to business, and possessed of an ample fortune, which permitted him, without inconvenience, to please his fancy in study, and in helping others with what to himself was superfluous. Such a character, though rare, may exist, without being the object of much respect. No: Mr Tschirnhaus was really a philosopher of the true stoic sect, in respect of fortitude of mind, while a good Christian in modesty and diffidence. In the last five years of his life he bore up under troubles, and embarrassments, and misfortunes in his family, which would have tried the mind of Cato himself. But in the midst of these storms he was unshaken, and preserved his serenity of mind. He was even sensible of this being a rare gift of Providence, and used frequently to express his thankfulness for a treasure so precious. He felt deeply his relation to the Author of Nature, and rejoiced in thinking himself subject to the providence of God. He said that he was fully persuaded that he would meet with perfect justice, and would therefore strive to perform his own part to the utmost of his power, that his future condition might be the more happy, and that he might in the mean time enjoy more satisfaction on reflecting on his own conduct. His lot, he said, was peculiarly fortunate: having such thirst for novelty, he would have been unhappy without an affluent fortune; and his own enjoyments encouraged neither vice nor idleness in himself or in the ministers to his pleasures.

This amiable person was of a constitution not puny, but not robust, and he had hurt it by too constant study. He feared no disease; thinking that he had a cure or an alleviation for all but one, namely, the stone and gravel. He had a dread of this, and laboured to find a preventative or a remedy. He thought that he had also done a great deal here; and describes in his *Medicina Corporis* a preparation of whey, which he said he used with great advantage to his health. But his precautions were in vain: He was attacked with the gravel, which, after three months suffering, brought on a suppression of urine. The physicians saw that his end approached; and finding him disregard their prescriptions, they quitted him. He treated himself (it is said judiciously) for some time, and with some appearance of success; but at last he saw death not far off. He dictated a letter to his Sovereign, thanking him for all his favours and kindness, and recommended his children to his protection. He never fretted nor complained; but frequently, with glistening eyes, expressed his warmest thanks to Providence for the wonderful track of good fortune and of happiness that he had enjoyed; and said that he also felt some satisfaction in the consciousness that some of this was owing to his own prudent conduct. He possessed his entire faculties to the last moment; and when he felt his spirit just about to depart, his last words were, "*Jö triumphe—Victoria!*" No longer able to speak, he made signs for what he wanted; and a little after, shutting his eyes, as if to sleep, he gently, and without a groan, yielded up his spirit, about four o'clock in the morning of the 11th of October 1708, aged 56.

His funeral was performed in a manner becoming his rank, and the body conveyed to the family vault. The Elector (King of Poland) defrayed the expence; for he would not allow his family to have any thing to do with the funeral of a man of so public a character, and so universally beloved.

The account of such a life as that of Baron Von Tschirnhaus would, at all times, make a pleasant and useful impression. In these our times, in the end of the 18th century, after society has availed itself of all the acquisitions in science and art, furnished by that ardent age of the world which this gentleman contributed to adorn; in an age when we boast of illumination unparalleled in history, and of improvements almost amounting to perfection; and in particular, of an emancipation from the prejudices which had obscured our view of the chief good, and stifled public spirit—now, when we are so full of knowledge that it is running over on all hands, in volumes of instruction, how to make the world one happy family; in these bright days of philanthropism, can the public records of Europe exhibit a superior character to that of Mr Von Tschirnhaus, either in respect of wisdom or of disposition? Was he not a philanthropist, a sincere lover of mankind? Was he not wise, in employing his great acquired knowledge as the means of direct and active beneficence, by limiting his exertions to the extent of those circles where his own efforts would be effective? He did not write books, teaching others how to do good: he taught it by example; being determined that his own wishes to see men happier should not fail by the want of such wishes in others, even after he should instruct them. He never allowed his insatiable curiosity for fresh discoveries to interfere with the immediate turning to the good of his own country the knowledge he had already acquired. He probably never thought of improving the situation of the Chinese or the Mexicans, finding that it required all his ample fortune, and all the interest and influence he could acquire, to do the good he wished in Saxony. We doubt not but that he was equally attentive to the still

still narrower circle of duties formed by his own family. We see that he was a dearly beloved brother; which could hardly be without his also being a loving brother and a dutiful son. The nature of the distresses which he experienced in his family, and the manner in which he behaved under them, shew him to have been an eminent Christian moralist. With a modesty that is unmatched by any one of the thousands who have poured out instructions upon us during the last ten years, and a gracefulness which characterises the gentleman, his *Medicina Mentis* is offered to public notice, merely as an experimental proof that a certain way of thinking and acting is productive of internal quiet of mind; of great mental enjoyment, both moral and intellectual; and of peace, and the good will of those around us: and that it did, in fact, produce a dutiful and comfortable resignation to the unavoidable trials of human life. He pretends not to be greatly superior in wisdom to his neighbours, but merely tells how things succeeded with himself. He did not scruple, however, to publish to the world discoveries in science, in which he had got the start of others during that busy period of scientific occupation: and these discoveries in mathematics were highly prized by the first men of the age; nor will the name of Tschirnhaus, or his caustic curves, ever be forgotten.

We felt ourselves obliged to the friend who took notice of the omission of this gentleman's name, so eminent in the mathematical world, in the course of our alphabet; but when we looked into the Memoirs of the Academy of Paris for 1709 for some account of him, what we there saw appeared such a continual panegyric, that we could not take it as a fair picture of any real character. Looking about for more impartial information, we found in the *Acta Eruditorum*, Leipf. 1709, the account of which the foregoing is an abstract, except a particular or two which we have copied from an account in the Literary Journal of Breslaw, by Count Herberstein, whom we can scarcely suspect of undue partiality, because he had some disputes with Mr Von Tschirnhaus on mathematical subjects. May we not say, "the memory of this man is sweet!"

TSHAMIE, the Indian name of a tree in the Northern Circars of Hindostan. It grows, says Dr Roxburgh, to be a pretty large tree, is a native of most parts of the coast, chiefly of low lands at a considerable distance from the sea, and may be only a variety of *prosopis spicigera*, for the thorns are in this sometimes wanting; flowers during the cold and beginning of the hot seasons. *Trunk* tolerably erect, bark deeply cracked, dirty ash colour. *Branches* irregular, very numerous, forming a pretty large shady head. *Prickles* scattered over the small branches; in some trees wanting. *Leaves* alternate, generally bipinnate, from two to three inches long; pinnæ from one to four, when in pairs opposite, and have a gland between their insertions. *Leaflets* opposite, from seven to ten pair, obliquely lanced, smooth, entire, about half an inch long, and one-sixth broad. *Stipules* none. *Spikes* several, axillary, filiform, nearly erect. *Bracts* minute, one-flowered, falling. *Flowers* numerous, small, yellow, single, approximated. *Calyx* below, five-toothed. *Filaments* united at the base. *Anthers* incumbent, a white gland on the apex of each, which falls off soon after the flower expands. *Style* crooked. *Stigma* simple. *Legume* long, pendulous, not inflated. *Seeds* many, lodged in a brown meally substance.

The pod of this tree is the only part used. It is about an inch in circumference, and from six to twelve long; when ripe, brown, smooth, and contains, besides the seeds, a large quantity of a brown meally substance, which the natives eat; its taste is sweetish and agreeable; it may therefore be compared to the Spanish *algaroba*, or locust tree. (*Ceratonia siliqua*, Linn.)

In compliance with Dr Kœnig's opinion, Dr Roxburgh calls this tree a *prosopis*; but as he thinks the antheral glands give it a claim to the genus *adenanthera*, we have retained the Indian name till its botanical classification shall be ascertained by those who have greater authority in the science than we lay claim to.

TUCKER (Abraham), Esq; a curious and original thinker, was a gentleman of affluent fortune, and author of "The Light of Nature pursued," 9 vols 8vo; of which the five first volumes were published by himself in 1768, under the assumed name of "Edward Search, Esq;" and the four last after his death, in 1775, as "The posthumous Work of Abraham Tucker, Esq; published from his manuscript as intended for the press by the author." Mr Tucker lived at Betchworth-castle, near Dorking, in Surrey; an estate which he purchased in the early part of his life. He married the daughter of Edward Barker, Esq; by whom he had two daughters; one of whom married Sir Henry St John, and died in his lifetime; the other survived, and now lives at Betchworth-castle. He lost his eyesight a few years before his death, which happened in 1775. To describe him as a neighbour, landlord, father, and magistrate, it would be necessary to mention the most amiable qualities in each. It is unnecessary to add, that he was very sincerely regretted by all who had the pleasure of his acquaintance, and who stood connected with him in any of those relations.

Tucker (Josiah, D. D.), well known as a political and commercial writer, was born at Langhorn, in Caermarthenshire, in the year 1712. His father was a farmer, and having a small estate left him at or near Aberystwith, in Cardiganshire, he removed thither; and perceiving that his son had a turn for learning, he sent him to Ruthin school, in Denbighshire, where he made so respectable a progress in the classics, that he obtained an exhibition at Jesus College, Oxford. It is generally understood that several of his journeys to and from Oxford were performed on foot, with a stick on his shoulder, and bundle at the end of it. Thus it might be said by him, as by Simonides, "*Omnia mea mecum porto.*"

At the age of 23 he entered into holy orders, and served a curacy for some time in Gloucestershire. About 1737 he became curate of St Stephen's church in Bristol, and was appointed minor-canon in the cathedral of that city. Here he attracted the notice of Dr Joseph Butler, then Bishop of Bristol, and afterwards of Durham, who appointed Mr Tucker his domestic chaplain. By the interest of this prelate Mr Tucker obtained a probendal stall in the cathedral of Bristol; and on the death of Mr Catcott, well known by his treatise on the Deluge, and a volume of excellent sermons, he became rector of St Stephen. The inhabitants of that parish

confist chiefly of merchants and tradefmen: a circumftance which greatly aided his natural inclination for commercial and political ftudies.

When the famous bill was brought into the Houfe of Commons for the naturalization of the Jews, Mr Tucker, confidering the meafure rather as a merchant or politician than as a Chriftian divine, wrote in defence of it with a degree of zeal which, to fay no more, was at leaft indecent in a man of his profeffion. As fuch it was viewed by his brethren of the clergy, and by his parifhioners; for, while the former attacked him in pamphlets, newfpapers, and magazines, the latter burnt his effigy dreffed in canonicals, together with the letters which he had written in defence of the naturalization.

In the year 1753 he publifhed an able pamphlet on the "Turkey Trade;" in which he demonftrates the evils that refult to trade in general from chartered companies. At this period Lord Clare (afterward Earl Nugent) was returned to Parliament for Briftol; which honour he obtained chiefly through the ftrenuous exertions of Mr Tucker, whofe influence in his large and wealthy parifh was almoft decifive on fuch an occafion. In return for this favour, the Earl procured for him the deanery of Gloucefter, in 1758, at which time he took his degree of doctor in divinity. So great was his reputation for commercial knowledge, that Dr Thomas Hayter, afterwards Bifhop of London, who was then tutor to his prefent majefty, applied to Dr Tucker to draw up a differtation on this fubject for the perufal of his royal pupil. It was accordingly done, and gave great fatisfaction. This work, under the title of "The Elements of Commerce," was printed in quarto, but never publifhed.

Dr Warburton, who became Bifhop of Gloucefter in the year 1760, thinking very differently from Dr Tucker of the proper ftudies of a clergyman, as well as of the project for naturalizing the Jews, faid once to a perfon who was praifing the Elements of Commerce, that "his Dean's trade was religion, and religion his trade." This farcafm, though not perhaps groundlefs, was certainly too fevere; for fome of the Dean's publications evince him to have devoted part of his time at leaft to the ftudy of theology, and to have been a man of genuine benevolence.

In the year 1771, when a ftrong attempt was made to procure an abolition of fubfcription to the 39 articles, Dr Tucker came forward as an able and moderate advocate of the church of England. About this time he publifhed "Directions for Travellers;" in which he lays down excellent rules, by which gentlemen who vifit foreign countries may not only improve their own minds, but turn their obfervations to the benefit of their native country.

The Dean was an attentive obferver of the American conteft. He examined the affair with a very different eye from that of a party man, or an interefted merchant; and he difcovered, as he conceived, that both fides would be better off by an abfolute feparation. Mr Burke's language in the Houfe of Commons, in confequence of his publifhing this opinion, was harfh, if not illiberal. In his famous fpeech on the American taxation bill, April the 13th, 1774, he called the Dean of Gloucefter the advocate of the court faction, though it is well known that the court difapproved of the propofal as much as the oppofition. This attack roufed the Dean to refentment; and he publifhed a letter to Mr Burke; in which he not only vindicates the purity of his own principles, but retorts upon his adverfary in very forcible and farcaftic terms. He afterwards fupported Lord Nugent's intereft in Briftol againft that of Mr Burke, and was certainly very inftrumental in making the latter lofe his election.

When the terrors of an invafion were very prevalent in 1779, Dr Tucker circulated, in a variety of periodical publications, fome of the moft fenfible obfervations that were ever made on the fubject, in order to quiet the fears of the people. In 1781 he publifhed, what he had printed long before, "A Treatife on Civil Government," in which his principal defign is to counteract the doctrines of Locke and his followers. The book made a confiderable noife, and was very fharply attacked by feveral writers on the democratic fide of the queftion, particularly by Dr Towers and Dr Dunbar of Aberdeen. This laft gentleman acted a part which, if not difhonourable, was at leaft uncommon. The Dean had thrown off thirty copies of his work long before he publifhed it; and thefe he fent to different men of eminence, that he might avail himfelf of their animadverfions before he fhould fubmit it to the public at large. Principal Campbell of Aberdeen received one copy for this purpofe; and Dr Dunbar having by him been favoured with a perufal of it, inftead of fending his objections privately to the author, publifhed fevere remarks on it in a work which he had then in the prefs. Thus was the anfwer to the Dean of Gloucefter's Treatife on Government publifhed before that treatife itfelf; but Dr Dunbar was no match for Dr Tucker.

In the year 1782 our author clofed his political career with a pamphlet intitled "*Cui Bono?*" in which he balances the profit and lofs of each of the belligerent powers, and recapitulates all his former pofitions on the fubject of war and colonial poffeffions. His publications fince that period confifted of fome tracts on the commercial regulations of Ireland, on the exportation of woollens, and on the iron trade. In 1777 he publifhed feventeen practical fermons, in one volume octavo. In the year 1778, one of his parifhioners, Mifs Pelloquin, a maiden lady of large fortune and moft exemplary piety, bequeathed to the Dean her dwelling-houfe in Queen Square, Briftol, with a very handfome legacy, as a teftimony of her great efteem for his worth and talents. In the year 1781 the Dean married a lady of the name of Crowe, who refided at Gloucefter.

It fhould be recorded to his praife, that though enjoying but very moderate preferment (for to a man of no paternal eftate, or other ecclefiaftical dignity, the Deanery of Gloucefter is no very advantageous fituation), he was notwithftanding a liberal benefactor to feveral public inftitutions, and a diftinguifhed patron of merit. The celebrated John Henderfon of Pembroke-college, Oxford, was fent to the univerfity, and fupported there, at the Dean's expence, when he had no means whatever of gratifying his ardent defire for ftudy. We fhall mention another inftance of generofity in this place, which reflects the greateft honour upon the Dean. About the year 1790 he thought of refigning his rectory in Briftol, and, without communicating his defign to any other perfon, he applied to the Chancellor, in whofe

Tucker. Tulipomania.

whose gift it is, for leave to quit it in favour of his curate, a most deserving man, with a large family. His Lordship was willing enough that he should give up the living, but he refused him the liberty of nominating his successor. On this the Dean resolved to hold the living himself till he could find a fit opportunity to succeed in his object. After weighing the matter more deliberately, he communicated his wish to his parishioners, and advised them to draw up a petition to the Chancellor in favour of the curate. This was accordingly done, and signed by all of them, without any exception, either on the part of the dissenters or others. The Chancellor being touched with this testimony of love between a clergyman and his people, yielded at last to the application; in consequence of which the Dean cheerfully resigned the living to a successor well qualified to tread in his steps. Since that time he resided chiefly at Gloucester, viewing his approaching dissolution with the placid mind of a Christian, conscious of having done his duty both to God and man. He died in November 1799. The following we believe to be a tolerably correct list of his works.

Theological and Controversial.—1. A Sermon, preached before the Governors of the Infirmary of Bristol, 1745. 2. Letters in behalf of the Naturalization of the Jews. 3. Apology for the Church of England, 1772. 4. Six Sermons, 12mo, 1773. 5. Letter to Dr Kippis on his Vindication of the Protestant Dissenting Ministers. 6. Two Sermons and Four Tracts. 7. View of the Difficulties of the Trinitarian, Arian, and Socinian Systems, and Seventeen Sermons, 1777.

Political and Commercial.—8. A pamphlet on the Turkey Trade. 9. A brief View of the Advantages and Disadvantages which attend a Trade with France. 10. Reflections on the Expediency of Naturalizing foreign Protestants, and a Letter to a Friend on the same Subject. 11. The Pleas and Arguments of the Mother Country and the Colonies stated. 12. A Letter to Mr Burke. 13. Quere, Whether a Connection with, or Separation from, America, would be for national Advantage? 14. Answers to Objections against the Separation from America. 15. A Treatise on Civil Government. 16. *Cui Bono?* 17. Four Letters on national Subjects. 18. Sequel to Sir William Jones on Government. 19. On the Dispute between Great Britain and Ireland. 20. Several Papers under the Signature of Cassandra, &c. on the Difficulties attendant on an Invasion. 21. A Treatise on Commerce (Mr Coxe, in his Life of Sir Robert Walpole, says that this was printed, but never published.)

Miscellaneous.—22. Directions for Travellers. 23. Cautions against the Use of Spirituous Liquors. 24. A Tract against the Diversions of Cock-fighting, &c.

TULIPOMANIA, the very proper name given to a kind of gambling traffic in *tulip-roots*, which prevailed in Holland and the Netherlands during some part of the 17th century. It was carried on to the greatest extent in Amsterdam, Haerlem, Utrecht, Alkmaar, Leyden, Rotterdam, Hoorn, Enkhuysen, and Meedenblick; and rose to the greatest height in the years 163[illegible], 1635, 1636, and 1637. Munting, who, in 16[illegible]6, wrote a book of [illegible]000 pages folio on the subject, has given a few of the most extravagant prices, of which we shall present the reader with the following. For a root of that species called the *Viceroy*, the after-mentioned articles, valued as below, were agreed to be delivered.

	Florins.
2 lasts of wheat	448
4 ditto rye	558
4 fat oxen	480
8 fat swine	240
12 fat sheep	120
2 hogsheads of wine	70
4 tons beer	32
2 ditto butter	192
1000 pounds of cheese	120
a complete bed	100
a suit of clothes	80
a silver beaker	60
Sum	2500

These tulips afterwards were sold according to the weight of the roots. Four hundred perits* of Admiral Liefken cost 4400 florins; 446 ditto of Admiral Von der Eyk, 1620 florins; 106 perits Schilder cost 1615 florins; 200 ditto Semper Augustus, 5500 florins; 410 ditto Viceroy, 3000 florins, &c. The species Semper Augustus has been often sold for 2000 florins; and it once happened that there were only two roots of it to be had, the one at Amsterdam and the other at Haerlem. For a root of this species, one agreed to give 4600 florins, together with a new carriage, two grey horses, and a complete harness. Another agreed to give twelve acres of land for a root: for those who had not ready money, promised their moveable and immoveable goods, house and lands, cattle and clothes. A man, whose name Munting once knew, but could not recollect, won by this trade more than 60,000 florins in the course of four months. It was followed not only by mercantile people, but also by the first noblemen, citizens of every description, mechanics, seamen, farmers, turf-diggers, chimney-sweeps, footmen, maid-servants, and old clothes women, &c. At first, every one won and no one lost. Some of the poorest people gained in a few months houses, coaches, and horses, and figured away like the first characters in the land. In every town some tavern was selected which served as a change, where high and low traded in flowers, and confirmed their bargains with the most sumptuous entertainments. They formed laws for themselves, and had their notaries and clerks.

* A *perit* is a small weight less than a grain.

To get possession of fine flowers was by no means the real object of this trade, though many have said that it was, and though we have known some individuals in Scotland, who, led away by what they thought the fashion, have given ten guineas for a tulip root. During the time of the tulipomania, a speculator often offered and paid large sums for a root which he never received, and never wished to receive. Another sold roots which he never possessed or delivered. Oft did a nobleman purchase of a chimney-sweep tulips to the amount of 2000 florins, and sold them at the same time to a farmer; and neither the nobleman, chimney-sweep, or farmer, had roots in their possession, or wished to possess them. Before the tulip season was over, more roots were sold and purchased, bespoke, and promised to be delivered, than in all probability were to be found in the gardens of Holland; and when Semper Augustus was

Tulipomania.

was not to be had, which happened twice, no species perhaps was oftener purchased and sold. In the space of three years, as Munting tells us, more than ten millions were expended in this trade in only one town of Holland.

To understand this gambling traffic, it may be necessary to make the following supposition. A nobleman bespoke of a merchant a tulip root, to be delivered in six months, at the price of 1000 florins. During these six months the price of that species of tulip must have risen or fallen, or remained as it was. We shall suppose that, at the expiration of that time, the price was 1500 florins; in that case, the nobleman did not wish to have the tulip, and the merchant paid him 500 florins, which the latter lost and the former won. If the price was fallen when the six months were expired, so that a root could be purchased for 800 florins, the nobleman then paid to the merchant 200 florins, which he received as so much gain; but if the price continued the same, that is, 1000 florins, neither party gained or lost. In all these circumstances, however, no one ever thought of delivering the roots or of receiving them. Henry Munting, in 1636, sold to a merchant at Alkmaar, a tulip root for 7000 florins, to be delivered in six months; but as the price during that time had fallen, the merchant paid, according to agreement, only 10 *per cent.* "So that my father (says the son) received 700 florins for nothing; but he would much rather have delivered the root itself for 7000." The term of these contracts was often much shorter, and on that account the trade became brisker. In proportion as more gained by this traffic, more engaged in it; and those who had money to pay to one, had soon money to receive of another; as at faro, one loses upon one card, and at the same time wins on another. The tulip dealers often discounted sums also, and transferred their debts to one another; so that large sums were paid without cash, without bills, and without goods, as by the Virements at Lyons. The whole of this trade was a game at hazard, as the Mississippi trade was afterwards, and as stock jobbing is at present. The only difference between the tulip trade and stock-jobbing is, that at the end of the contract the price in the latter is determined by the Stock Exchange; whereas in the former it was determined by that at which most bargains were made. High and low priced kinds of tulips were procured, in order that both the rich and the poor might gamble with them; and the roots were weighed by perits, that an imagined whole might be divided, and that people might not only have whole, but half and quarter lots. Whoever is surprised that such a traffic should become general, needs only to reflect upon what is done where lotteries are established, by which trades are often neglected, and even abandoned, because a speedier mode of getting fortunes is pointed out to the lower classes.

At length, however, this trade fell all of a sudden. Among such a number of contracts many were broken; many had engaged to pay more than they were able; the whole stock of the adventurers was consumed by the extravagance of the winners; new adventurers no more engaged in it; and many becoming sensible of the odious traffic in which they had been concerned, returned to their former occupations. By these means, as the value of tulips still fell, and never rose, the sellers wished to deliver the roots *in natura* to the purchasers at the prices agreed on; but as the latter had no desire for tulips at even such a low rate, they refused to take them or to pay for them. To end this dispute, the tulip-dealers of Alkmaar sent, in the year 1637, deputies to Amsterdam; and a resolution was passed on the 24th of February, that all contracts made prior to the last of November 1636 should be null and void; and that, in those made after that date, purchasers should be free on paying ten *per cent.* to the vender.

The more disgusted people became with this trade, the more did complaints increase to the magistrates of the different towns; but as the courts there would take no cognizance of it, the complainants applied to the States of Holland and West Friesland. These referred the business to the determination of the provincial council at the Hague; which, on the 27th of April 1637, declared that it would not deliver its opinion on this traffic until it had received more information on the subject; that in the mean time every vender should offer his tulips to the purchaser; and, in case he refused to receive them, the vender should either keep them, or sell them to another, and have recourse on the purchaser for any loss he might sustain. It was ordered also, that all contracts should remain in force till farther enquiry was made. But as no one could foresee what judgment would be given respecting the validity of each contract, the buyers were more obstinate in refusing payment than before; and venders, thinking it much safer to accommodate matters amicably, were at length satisfied with a small profit instead of exorbitant gain: and thus ended this extraordinary traffic, or rather gambling. *Beckmann's History of Inventions*, vol. i.

Tulipomania || Turnsol.

TUMAR, in Bengal, rent-roll or assessment.

TUMBREL, is a kind of carriage with two wheels, used either in husbandry for dung, or in artillery to carry the tools of the pioneers, &c. and sometimes likewise the money of an army.

TUNGSTEN (see CHEMISTRY, n° 178, &c. in this *Suppl.*) when well fused, is, according to Guyton *alias* Morveau, of no higher specific gravity than 8.3406. This is very different from the specific gravity which has hitherto been assigned to it. The same eminent chemist concludes, from its extreme brittleness and difficulty of fusion, that it affords little promise of utility in the arts, except in metallic alloys, or by virtue of the property which its oxyd possesses, of affording fixed colours, or giving fixity to the colours of vegetables.

TURNSOL, a dye-stuff manufactured in Holland, the preparation of which was long kept a profound secret. In order to mislead foreigners, the Dutch pretended that turnsol was made from rags dyed with the juice of the sun-flower (*Helianthus*), from which it obtained its name. Since the late revolution, however, in Holland, the true method employed by the Dutch for preparing this colour has been discovered, and the process is as follows:—That kind of lichen called orchil (LICHEN-*Rocella*. See that article in this *Suppl.*), or, when that cannot be procured, the large oak-moss, after being dried and cleaned, is reduced to powder, and by means of a kind of oil-press the powder is forced thro' a brass sieve, the holes of which are small. The sifted powder is then thrown into a trough and mixed with an alkali called *vetas*, which is nothing else than the ashes

ashes of wine lees, in the proportion of half a pound of ashes to one pound of powder. This mixture is moistened with a little human urine, for that of other animals contains less ammonia, by which a fermentation is produced; and the moistness is still kept up by the addition of more urine. As soon as the mixture assumes a red colour, it is poured into another trough; is again moistened with urine, and than stirred round in order that the fermentation may be renewed. In the course of a few days it acquires a bluish colour, and is then carefully mixed with a third part of very pure pulverised potash; after which the mixture is put into wooden pails, three feet in height, and about half a foot broad. When the third fermentation takes place, and the paste has acquired a considerably dark blue colour, it is mixed with chalk or pulverised marble, and stirred well round that the whole may be completely united. This last substance gives the colour no higher quality, and is intended merely to add to the weight. The blue, prepared in this manner, is poured into oblong square iron moulds; and the cakes, when formed, are placed upon fir boards on an airy floor in order to dry, after which they are packed up for sale.

TURPENTINE, a well known substance extracted from the pine. Under the article PINUS (*Encycl.*), we have given an account of one process by which this extract is made; but the following, which is taken from the 31st volume of the *Journal de Physique*, is very different, and probably better. The pine from which turpentine is extracted, is never fit for this operation till it be thirty years of age. The extraction is begun in February and continued to the end of October. Incisions are made with an hatchet, beginning at the foot of the tree on one side, and rising successively: they are repeated once or twice a week, the size about one finger's breadth across, and three or four inches long. During the four years in which it is continued, the incisions have risen to about eight or nine feet. Then the incisions are begun on the other side; and during this time the old ones fill up, and may be again opened after some years, so that a tree on a good soil, and well managed, may yield turpentine for a century. At the bottom of the tree, under the incision, a hole is dug in the ground to receive the resin which flows from the tree. This resin is called *terebinthine brut*, is of a milky colour, and is that which flows during the three summer months; it requires further purification.

The winter crop is called *barras galipot*, or white resin: it sticks to the bark of the tree, when the heat has not been strong enough to let it flow into the trough in the ground. It is scraped off with iron knives.

Two methods are practised for purifying these resins. That which is followed at Bayonne is to have a copper cauldron which will hold 300lb. of materials fixed over a fire, and the flame circulating at the bottom of the copper. The turpentine is put in, melted with a gentle heat, and, when liquid, it is strained through a straw-basket made for the purpose, and stretched over a barrel, which receives the strained turpentine. This purification gives it a golden colour, and may be performed at all times of the year.

The second manner, which is practised only in the mountain of De Buch, near Bourdeaux, consists in having a large tub, seven or eight feet square, and pierced with small holes at the bottom, set upon another tub to catch the liquor. This is exposed to the hottest sun for the whole day, filled two thirds with turpentine, which as it melts falls through the holes, and leaves the impurities behind. This pure turpentine is less golden-coloured, and is much more esteemed than the other. This process can only be done in the summer.

To make *oil* of turpentine, an alembic, with a worm like what is used by the distillers, is employed here. It generally contains 250lb. of turpentine, which is boiled gently, and kept at the boiling point till no more oil passes, when the fire is damped This generally gives 60lb. of oil, and the operation lasts one day

The boiling turpentine, when it will give no more oil, is tapped off from the still and flows into a tub, and from thence into a mold of sand, which it fills, and is suffered to cool for at least two days without disturbing it. This residue is known under the name of *colo fone*. It is of a brown colour, and very dry. It may be made clearer and nearer in colour to that of the rosin, by adding hot water to it before it is tapped off the still, and still boiling and stirring the water well with it, which is done with a besom of wet straw; and it is then sold for rosin, but is little esteemed, as it contains no essential oil.

TUSCULANUM, a villa belonging to Cicero, near Tusculum, where he wrote his *Quæstiones Tusculanæ*, so named from the place; thus become famous as well for the productions of genius as of nature. Formerly the villa of Sylla: now called *Grotta Ferrata*.—Another *Tusculanum* (inscription), a town of the Transpadana, situated on the west side of the Lacus Benacus. Now said to be called *Toscolaro*, in the territory of Brescia, subject to Venice. Here many monuments of antiquity are dug up.

TUSCULUM (anc. geog.), a town of Latium, to the north of Alba; situated on an eminence, and therefore called *Supernum* (Horace, Strabo). In sight of Rome, at about the distance of 100 stadia, or 12 miles. Adorned with plantations and princely edifices: the spot remarkable for the goodness of the soil, and its plenty of water. Built by Telegonus, who slew his father Ulysses (Ovid, Horace); called the grandson of Ulysses in Silius Italicus. A municipium (Cicero); the birth-place of the elder Cato (Nepos, Cicero). Now *Frescati*, in the Campania of Rome.

TUTENAG, according to Sir George Staunton, is, properly speaking, zinc extracted from a rich ore, or calamine. The ore is powdered and mixed with charcoal-dust, and placed in earthen jars over a slow fire, by means of which the metal rises in the form of vapour, in a common distilling apparatus, and afterwards is condensed in water. The calamine from which tutenag is thus extracted, contains very little iron, and no lead or arsenic, so common in the calamine of Europe (See CALAMINE, *Encycl.*) Hence it is that tutenag is more beautiful than our zinc, and that the white copper of the Chinese takes so fine a polish. See *White Copper*, in this *Supplement*.

TYERS (Thomas), an author both in poetry and prose, the friend of Johnson, and well known to most of the eminent characters of the present time, was a student of the Temple in 1753. His father intended him for the law, but the young man it seems penned a sonnet when he should engross. He was an accomplished, but not a profound man; and had taste and ele-

Typography.

gance of mind, ſlightly tinged with gleams of genius. He wrote ſome paſtorals and political tracts, which probably will not ſurvive the partiality of his particular friends.

TYPOGRAPHY, as the word imports, is the art of printing by types; but it is likewiſe uſed to ſignify the multiplying of copies by any mechanical contrivance. Of the art of printing by types, and the many improvements from time to time either made or attempted in it, a pretty full account will be found in the *Encyclopædia*, under the titles LETTER, LOGOGRAPHY, and PRINTING; and in this *Supplement* under the word PRINTING. Of typography, in the other and larger ſenſe, ſome account may likewiſe be found in the *Encyclopædia* under the title *Method of Copying* WRITINGS; but to almoſt all theſe articles there is ample room for ſome additions here.

The *ſtereotype* printing of *Didot* and *Herhan*, being conſidered in France as a great improvement, muſt not be paſſed over wholly without notice. The term *ſtereotype* is derived from the Greek words στερεος and τυπος, becauſe in this method the types are fixed and immoveable in the form, ſo that none of them can be pulled or diſplaced by the preſſman. We need hardly obſerve, to thoſe who are at all acquainted with the hiſtory of printing, that the project of ſoldering a whole form together, or of caſting a ſolid form from an impreſſion made by a general ſyſtem of types, or page ready compoſed, is not new. It was realiſed 70 years ago by WILLIAM GED, a goldſmith in Edinburgh; for an account of whoſe method we refer the reader to his life in the *Encyclopædia*. Didot now follows nearly the ſame proceſs as Ged. He does not indeed caſt his types in a maſs, but after the form is compoſed and carefully corrected, he cements or ſolders the types together ſo firmly that none of them is liable to be looſened by the action of the preſs or the adheſion of the balls. How far this method of printing is of value with regard to books which are altered and improved in every ſubſequent edition, may, perhaps, be queſtioned; but on a looſe conſideration of the ſubject, it ſeems as if it would, in every caſe, be advantageous to a bookſeller to print a few copies of a work, and keep the types ſtanding to print others as they may be wanted;—we ſay it would be advantageous, if it were not for the immenſe value in types, which would, by that means, be locked up. To form ſome judgment of this, it may be ſtated, that the works of Virgil, printed by Didot, in 18mo, form a beautiful volume of 418 pages, of 35 lines each. The character ranges line for line with that called burgeois, N° 2. in Caſlon's book of ſpecimens, the face of the letter being rather ſmaller; and we are told * that the price of the plates of this work is twelve hundred franks, or 50l. ſterling. From this fact ſome judgment may be formed of the commercial queſtion. We have caſually looked at different books printed by Didot, but can ſay nothing of their correctneſs: the page is very pretty.

* *La Decade Philoſophique.*

For multiplying copies of any writing, or of a book of ordinary ſize, Rochon, of the French National Inſtitute, and now Director of the Marine Obſervatory at the port of Breſt, invented, about the year 1781, a machine for engraving, with great celerity and correctneſs, the pages of the book or manuſcript on ſo many plates of copper. It was ſubmitted to the examination of a committee of the Royal Academy of Sciences, whoſe report of its utility was given in the following words:

"This machine appears to us to unite ſeveral advantages. 1*ſt*, Engraved editions of books may be executed, by this means, ſuperior to thoſe which can be made by the hand of the engraver, however ſkilful; and theſe engraved originals will be made with much more ſpeed, and much leſs expence. 2*d*, As this machine is portable, and of no conſiderable bulk, it may become very uſeful in armies, fleets, and public offices, for the impreſſion of orders, inſtructions, &c. 3*d*, It poſſeſſes the advantage which, in a variety of circumſtances, is highly valuable, of being capable of being uſed by any man of intelligence and ſkill, without requiring the aſſiſtance of any profeſſional workman. And, *laſtly*, It affords the facility of waiting for the entire compoſition and engravings of a work before any of the copies are pulled off; the expence of plates, even for a work of conſiderable magnitude, being an object of little charge; and this liberty it affords to authors, may prove highly beneficial in works of which the chief merit conſiſts in the order, method, and connection of ideas."

Rochon's machine conſiſts of two braſs wheels *, placed on the ſame axis above each other, and ſeparated by a number of pillars, each two inches in length. Theſe two wheels, with the interval which ſeparates them, are equivalent to a ſingle wheel about three inches thick. In order therefore to ſimplify the deſcription, they are conſidered as a ſingle wheel which moves freely on its axis.

* See Plate XLVI.

This wheel is perforated near its circumference with a number of ſquare holes, which are the ſheaths or ſockets through which a like number of ſteel punches, of the ſame ſhape, are inſerted, and are capable of moving up and down. They are very well fitted; and from this circumſtance, as well as the thickneſs of the double wheel, they have no ſhake, or ſide motion, independent of the motion of the wheel itſelf. Every punch is urged upwards by a ſeparate ſpring, in ſuch a manner, that the wheel armed with its characters, or ſteel types (the lower faces of the punches being cut into the figures of the ſeveral letters), may turn freely on its axis; and if it be moved, the ſeveral punches will paſs in ſucceſſion beneath an upright ſcrew, for preſſure. The ſcrew is fixed in a very firm and ſolid frame, attached to the ſupports of the machine; and by this arrangement a copperplate, diſpoſed on the table, or bed of the apparatus, will receive the impreſſion of all the punches in ſucceſſion, as they may be brought beneath the vertical preſſing ſcrew, and ſubjected to its action.

But as the preſs is fixed, it would neceſſarily follow that each ſucceſſive impreſſion would, in part, deſtroy or mutilate the previous impreſſions, unleſs the plate itſelf were moveable. It therefore becomes neceſſary that the plate ſhould be moveable in two directions: the firſt, to determine the interval between the letters and words, and form the lines; and the other motion, which is more ſimple, becauſe its quantity may remain the ſame through the whole of a book, ſerves to give the interval between line and line, and to form the pages.

It will eaſily be conceived that it would be a tedious operation to ſeek, upon the circumference of the wheel, each ſeveral character, as it might be required to come beneath

beneath the press, because it is necessary to repeat this operation as many times as there are characters in a work. The author has considerably diminished the time and trouble of this operation, by fixing upon the axis of the great wheel, which carries the punches, another small wheel, about four inches in diameter, the teeth of which act upon a rack, which carries a rule moving between two sliders. This rule, or straight line, will therefore represent the developement, or unfolding of the circumference of the wheel which causes it to move, and will shew the position of the great wheel, which carries the punches. For these two wheels being concentric, the developement of the small toothed wheel, of about two inches radius, will exhibit, in a small space (for example, that of a foot), an accurate register of the relative positions of the punches with regard to the pressing-screw. To obtain this effect, nothing more is necessary than to place a fixed index opposite to the moveable rule, which last is divided in the following manner:

The punch on which the first letter of the alphabet is engraved, must be brought under the centre of the pressing-screw; and a line of division then drawn upon the moveable rule, to which the letter itself must be added to distinguish it. The index, already mentioned, being placed opposite, and upon this first division, will serve to place immediately beneath the pressing-screw the punch, or rather the character, corresponding with the division upon the rule, without its being afterwards necessary to inspect the place either of the punch or the screw, with regard to each other. Consequently, as soon as the divisions which correspond with all the punches inserted in the wheel are engraved upon the straight rule, the fixed index will immediately determine the position into which that wheel must be brought, in order to place the punches under the pressing-screw in the order which the work may require.

This register, for this name distinguishes the rule and its index, has no other function in the machine than to guide the hand of the operator, and to shew when the punch is very near its proper position beneath the pressing-screw. When this is the case, the required position is accurately obtained by means of a detent or catch.

The detent which he uses for this operation is a lever with two tails, one of which is urged toward the circumference of the wheel by a spring. To this extremity of the lever is fixed a piece of hardened steel, of the figure of a wedge, which, by means of a spring, is pressed towards the axis of the great wheel, but may be relieved, or drawn back, by pressure on the opposite tail of the lever, so as to permit the great wheel to revolve at liberty.

In the next place, it must be explained how this detent takes hold of the wheel, so as to retain it precisely in the situation necessary to cause any one of the punches, at pleasure, to give its impression to the plate. For this purpose there are a number of notches cut in the circumference of the wheel, for the purpose of receiving the detent. These notches may be about half an inch deep, wider towards the circumference than elsewhere, and it will be of advantage that this outer width should be as great as the circumference of the wheel can conveniently allow. By this contrivance, the wedge will not fail to present itself opposite to one of the notches into which it will fall, and draw the wheel exactly to its due situation, even though the index of the register should not be brought precisely to the line of division appropriated to any particular letter. For if this last degree of precision were required in working the machine, it would be very prejudicial to the requisite speed which, above all things, is required in its use. When the wedge is therefore left at liberty, it not only enters immediately into its place, and moves the wheel till its two sides apply fairly to the interior surfaces of the notch, but retains the wheel in this state with the necessary degree of stability.

The method of giving the proper figure to these notches is very easy. For this purpose it is necessary, in the first place, to impress all the characters contained in the wheel on a plate of copper or pewter. The support on which the plate is fixed must be moved in a right line, after each stroke of the punch, through such a space that the characters may be arranged one after the other without touching. Now, as the perfect linear arrangement (supposing every other part to be true) must depend on the notches, it might seem sufficient to cut these according to the method used for the wheels of clock-work: but as it is very difficult to avoid some obliquity on the face of the punch, and perhaps in the hole through which it passes, it is in almost every case necessary to retouch the notch itself. The requisite degree of precision may be easily obtained, when, upon examining with attention the print of the characters engraved upon the plate, the inequalities shall have been ascertained by a very fine line passing exactly under the base of two similar letters, assumed as objects of comparison: for the irregularity of linear position may, by this means, be determined with great exactness, and remedied to the most extreme nicety. In this operation, the workman must file away part of that surface of the notch which is opposite to the direction of the motion the character requires. Great care must be taken to file only a small portion at a time, in order that the instant may be seized at which the wedge, by entering into the notch, brings the character to its due situation.

These details, respecting the right-lined arrangement on the characters, must not divert our attention from the very great celerity with which any letter is brought to its place under the press by means of the register and detent. This celerity is an object of so much importance in the engraving of a great work, that every means ought to be pursued which may tend to increase it. For this reason it is, that instead of following the alphabetic order in the arrangement of punches on the surface of the wheel, we ought to prefer that in which the sum of the different motions to be given to the wheel, for engraving an entire work, shall be the least possible. This tedious enquiry may well be dispensed with, by observing the order in which printers dispose their cases of characters, that the letters of the most frequent recurrence may be most immediately under the hand of the workman.

If all the characters afforded an equal resistance to impression in a plate of metal, a constant force would never fail to drive the punches to the same depth. But the faces of the letters are very unequal, and consequently it will be necessary to use a variable force. Most workmen use the hammer, and not a screw, as in this

this machine, for stamping. If the hammer had been used in this machine, it is evident, that if we supposed it to have fallen from the same height upon every one of the punches, the force of the stroke could be rendered variable according to the nature of the characters, by placing a capital, or head, upon each, of an height properly adjusted to receive the hammer after passing through a greater or less space. But the heads of our punches are variable at pleasure, because they are screwed on; and thus it is that, by experimentally adjusting the heads of all the punches, a set of impressions are obtained of equal depths from every one of them. When, for example, the letter *i* is placed under the hammer, the upper part of its head is at a small distance from the head of the hammer, in order that its fall, which begins always at the same place, may strike this letter weakly; but when the letter M is brought under the hammer, the upper part of its head being much less elevated than that of the letter *i*, will receive a much stronger blow. The impressions of the letters M and *i* will therefore always be equally deep, if the heads of the punches be once properly fixed by experiment.

Instead of the stroke of a hammer, however, our author makes use of the pressure of a screw, of which the threads are so inclined that it runs through its female socket, and would fall out merely by its own weight. This construction affords the double advantage of preserving the impressions from the effects of the circular motion, and of affording a fall in the screw of nearly nine lines for each revolution. The head of this screw is solidly fixed in the centre of a brass wheel, of which the position is horizontal. The diameter of this wheel must be sufficiently large, that its motion may not be perceptibly affected by the irregularities of friction in the screw. This considerable diameter is also requisite, because the pressure of the screw depends, not only upon the force which is applied, but the distance of the place of application from the centre of movement.

It is essential that this wheel should have very little shake; for which reason it is advisable that the axis of the screw should be prolonged above the wheel itself, that it may slide in a socket firmly fixed to the frame of the machine. In this situation, the wheel, which is fixed on the prolongation of the screw, will have its plane constantly preserved in a situation parallel to itself, without any libration, notwithstanding the rise and fall of near nine lines, or three quarters of an inch, which it undergoes for each revolution on its axis.

It has been stated, as a requisite condition, that the screw should constantly fall from the same fixed point, or elevation, upon the heads of every one of the punches. To accomplish this essential purpose, a lever is firmly fixed to the support of the screw; which lever resembles the beam of a balance, having one of its extremities armed with a claw, and the other serving to give it motion through a small vertical space. The claw falls into a notch in the upper surface of the wheel attached to the screw, as soon as that wheel has risen to the desired elevation; and the lever itself is so far limited in its motion, that it cannot take hold of the wheel, excepting when it has reached that height. The wheel, therefore, remains confined and immoveable, by means of this detent, and cannot descend until it is delivered by pressure upon the opposite tail of the lever. In this machine, the wheel which has the pressing screw for its axis does not perform an entire revolution. It was with a view that there might never be any fall capable of shaking and disturbing the machine that the author determined to use only two-thirds of a revolution to strike those punches, which afford the strongest resistance. The screw consequently falls only through six lines upon those heads which are least elevated, and about two lines upon those which stand highest. Whence the difference between the extreme heights does not exceed four lines.

It is obvious, that so small a difference is not sufficient to strike all the characters from M to the letter *i*, when the wheel which governs the screw is put in motion by a constant weight, of which the impulse, like that of a hammer, is increased only by the acceleration of its fall. It is evident that this requisite variation of force might be had by changing the weight; but it is equally clear, that the numberless and incessant changes which the engraving of an entire work would demand, would be incompatible with that degree of speed which forms one of the first requisites. He was therefore obliged to render the force of the weight, which turns the screw, variable, by causing it to act upon levers of greater or less lengths, according to the different quantities of impulse required by the several punches. For this purpose he adopted the following construction: He connected by a steel chain to the wheel, which moves the screw, another wheel, having its axis horizontal, so that the two wheels respectively command each other. They are of equal diameter, and the chain is no longer than to make an entire turn round each wheel. This second wheel, or leading pulley, is intended to afford the requisite variations of force, which it does by means of a snail fixed upon its axis. The snail is acted upon by a cord passing over its spiral circumference, or groove, and bearing a weight which is only to be changed when a new set of punches for characters of a different size are put into the great wheel. The spiral is so formed, that when the weight descends only through a small space, the part of the cord, which is unwound, acts at a very short distance from the centre of the pulley; but when the fall is greater, the part of the snail upon which it acts is so far enlarged as to afford a much longer lever, and, consequently, to give a proportionally greater effect to the stroke. This construction, therefore, by giving the advantage of a longer lever to a greater fall of the screw, affords all the power which the nature of the work, and the different spaces of the letters demand.

The support on which the plate is fixed must, as has before been remarked, move so as to form strait lines. This motion, which serves to space the different characters with precision, is obtained by means of a screw, the axis of which remains fixed, and carries a female screw or nut. The nut itself is attached to the support of the metallic plate, which receives the letters, and carries it in the right lined direction without any deviation; because it is confined in a groove formed between two pieces of metal. The screw is moved by a lever, which can turn it in one direction only, because it acts by a click upon a ratchet-wheel, which is fixed to the head of the screw. The action of this lever always begins from a fixed stop; but the space through which it moves is variable, according to the respective breadths of the letters. This new consideration induced M. Rochon to fix upon the rule or plate of the register, a number

PLATE XLVI.

ROCHON'S MACHINE FOR ENGRAVING METALLICK PLATES

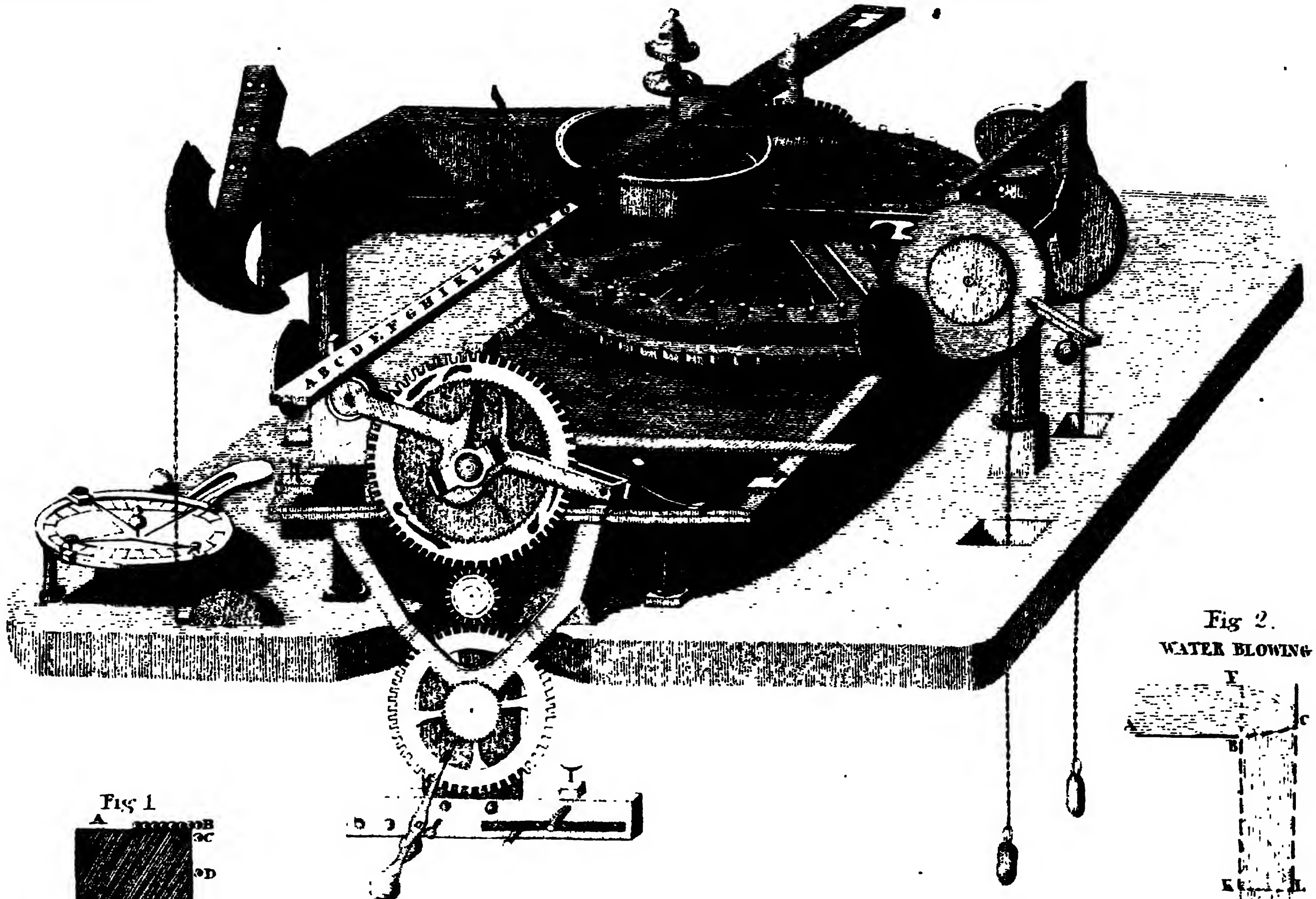


Fig 1

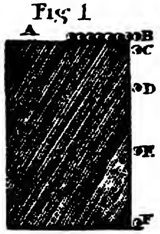
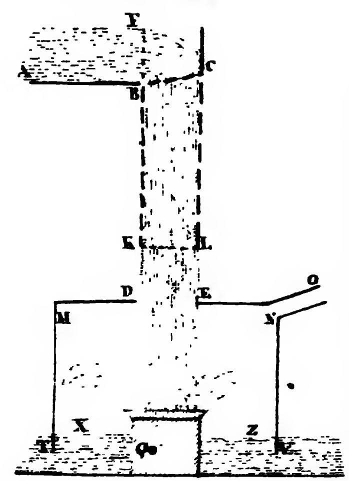


Fig 2.

WATER BLOWING



Typography || Tyrtæus.

number of pins, correfponding with the different divifions which anfwer to each punch: thefe pins determine the diftance to which the lever can move. It therefore becomes a condition, that its pofition in the machine fhould be oppofite to the fixed index which determines the character at any time beneath the preffing-fcrew. The lever and its pin are therefore the fole agents employed to fpace the characters. If the plate were not moved by the lever, the impreffions would fall upon each other; and thus, for example, the letter *i* would be totally obliterated by the impreffion of the letter *l*.

Whenever, therefore, it is required to difpofe the letters *i* and *l* befide each other, the plate muft be moved after ftriking the letter *i* through a fpace equal to the quantity of the defired operation. Suppofe this to be one-fourth of a line, and that the lever fhould run through an arc of ten degrees to move the plate thro' this quantity; as foon as the pin of the letter *l* fhall be adjufted to the neceffary length to enable the lever to defcribe an arc of ten degrees, the operation of fpacing the two letters *i* and *l* will be reduced to that of placing the laft letter beneath the fixed index, and moving the plate till the lever fhall be ftopped by the pin belonging to the letter *l*. All the other letters will be equally fpaced, if the difpofition of the punches in the wheel be fuch, that the laft ftroke of any letter fhall confound itfelf with any letter of a fingle ftroke, fuppofing them to be impreffed one after the other, without moving the lever between ftroke and ftroke. This arrangement deferves to be very ferioufly attended to, becaufe the procefs could not be performed without it.

Many well-informed perfons are of opinion, that the perfect equality which this machine for engraving affords in the formation of letters and figns the moft difficult to be imitated, may afford a means of remedying the dangers of forgery. It is certain that the performance exhibits a fimple and ftriking character of precifion, which is fuch, that the leaft experienced eyes might flatter themfelves, in certain cafes, to diftinguifh counterfeits from originals. Lavoifier, whom the friends of fcience and the arts will not ceafe to regret, made fome experiments of this kind for the *caiffe de'fcompte*, which were attended with perfect fuccefs. Artifts appointed for that purpofe endeavoured in vain to imitate a vignette, formed by the fucceffive and equal motion of a character of ornament.

TYRTÆUS, an Athenian general and mufician, is celebrated by all antiquity for the compofition of military fongs and airs, as well as the performance of them. He was called to the affiftance of the Lacedæmonians in the fecond war with the Meffenians, about 685 B. C.; and a memorable victory which they obtained over that people is attributed by the ancient fcholiafts upon Horace to the animating found of a new military flute or clarion, invented and played upon by Tyrtæus. Plutarch tells us that they gave him the freedom of their city; and that his military airs were conftantly fung and played in the Spartan army to the laft hour of the republic. And Lycurgus the orator, in his oration againft Leocrates, fays, "The Spartans made a law, that whenever they were in arms, and going out upon any military expedition, they fhould all be firft fummoned to the king's tent to hear the fongs of Tyrtæus;" thinking it the beft means of fending them forth in a difpofition to die with pleafure for their country. Fragments of his poetry, in elegiac verfe, are preferved in Stobæus, Lycurgus Orat. in Fulvius Urfinus, at the end of Poems by illuftrious Women; and in the Oxford edition of *Eleg. & Lyric. Frag. & Scholia.* printed 1759. [illegible], &c.

Tyler.

TYTLER (William, Efq;), fo well known in the literary world as one of the ableft, and certainly the moft gentlemanly, of the defenders of the fame of Mary Queen of Scots, was born at Edinburgh, October 12. 1711. He was the fon of Mr Alexander Tytler, writer (or attorney) in Edinburgh, by Jane, daughter of Mr William Leflie, merchant in Aberdeen, and grand-daughter of Sir Patrick Leflie of Idan, provoft of that city. He received his education at the grammar fchool (or, as it is there called, the High School) and the univerfity of his native city, and diftinguifhed himfelf by an early proficiency in thofe claffical ftudies, which, to the lateft period of his life, were the occupation of his leifure hours, and a principal fource of his mental enjoyments.

In the year 1731, he attended the academical lectures of Mr Alexander Bayne, Profeffor of municipal law in the univerfity of Edinburgh, a gentleman diftinguifhed alike for his profeffional knowledge, his literary accomplifhments, and the elegance of his tafte. The Profeffor found in his pupil a congenial fpirit: and their connection, notwithftanding the difparity of their years, was foon ripened into all the intimacy of the ftricteft friendfhip. So ftrong indeed became at length that tie of affection, that the worthy Profeffor, in his latter years, not only made him the companion of his ftudies, but when at length the victim of a lingering difeafe, chofe him as the comforter of thofe many painful and melancholy hours which preceded his death.

At the age of 31, Mr Tytler was admitted into the Society of Writers to his Majefty's Signet, and continued the practice of that profeffion with very good fuccefs, and with equal refpect from his clients and the public, till his death, which happened on the 12th of September 1792. He married, in September 1745, Anne Craig, daughter of Mr James Craig of Dalnair, writer to the fignet, by whom he has left two fons, Alexander Frafer Tytler, his Majefty's Judge advocate for Scotland, and Profeffor of civil hiftory in the univerfity of Edinburgh; and Patrick Tytler, Lieutenant colonel of a regiment of fencible infantry, and Fort major of the caftle of Stirling; together with one daughter, Mifs Chriftina Tytler. His wife died about nine years before him; and, previoufly to that period, he had loft a fon and a daughter, both grown to maturity.

The moft remarkable feature of Mr Tytler's character was an ardour and activity of mind, prompted always by a ftrong fenfe of rectitude and honour. He felt with equal warmth the love of virtue and the hatred of vice; he was not apt to difguife either feeling, nor to compromife, as fome men more complying with the world might have done, with the fafhion of the time, or the difpofition of thofe around him. He feldom waved an argument on any topic of hiftory, of politics, or literature; he never retreated from one on any fubject that touched thofe more important points on which he had formed a decided opinion. Decided opinions he always formed on fubjects of importance; for on fuch fubjects he formed no opinions rafhly; and what he firmly believed he avowed with confidence, and fometimes with warmth.

Nor was it in opinion or argument only that this warmth and ardour of mind were confpicuous. They prompted him equally in action and conduct. His affection to his family, his attachment to his friends and companions, his compaffion for the unfortunate, were alike warm and active. He was in fentiment alfo what Johnfon (who felt it ftrongly in himfelf, and mentions it as the encomium of one of his friends) calls a *good hater*; but his hatred or refentment went no further than opinion or words, his better affections only rofe into action. In his opinions, or in his expreffion of them, there was fometimes a vehemence, an appearance of acrimony, which his friends might regret, and which ftrangers might cenfure; but he had no afperity in his mind to influence his actual conduct in life. He indulged oppofition, not enmity; and the world was juft to him in return. He had opponents; but two of his biographers, who knew him well, as well as the people with whom he moft affociated, declare their belief that he had not a fingle enemy. His contefts were on opinions, not on things; his difputes were hiftorical and literary. In converfation, he carried on thefe with uncommon intereft and vivacity; and the fame kind of impulfe which prompted his converfation (as is juftly obferved by an author, who publifhed fome notices of his life and character in the periodical work intitled *The Bee*) induced him to become an author. He wrote not from vanity or vain glory, which Rouffeau holds to be the only inducement to writing; he wrote to open his mind upon paper; to fpeak to the public thofe opinions which he had often fpoken in private; opinions on the truth of which he had firmly made up his own conviction, and was fometimes furprifed when he could not convince others: it was fair to try, if, by a fuller expofition of his arguments, he could convince the world.

With this view, he publifhed, in 1759, his "Inquiry, hiftorical and critical, into the Evidence againft *Mary Queen of Scots*, and an Examination of the Hiftories of Dr Robertfon and Mr Hume with refpect to that Evidence;" in which he warmly efpoufed the caufe of that unfortunate Princefs, attacked with feverity the conduct of her enemies, and expofed the fallacy, in many parts the fabrication, of thofe proofs on which the charges againft her had been founded.

This was a caufe worthy of an advocate who loved truth better than popular applaufe; and Mr Tytler evinced himfelf to be fuch an advocate. The problem of Mary's guilt or innocence, if confidered merely as a detached hiftorical fact, would appear an object which, at this diftance of time, feems hardly to merit that laborious and earneft inveftigation to which it has given rife; though, even in this point of view, the mind is naturally ftimulated to fearch out the truth of a dark myfterious event, difgraceful to human nature; and our feelings of juftice and moral rectitude are interefted to fix the guilt upon its true authors. But when we confider that this queftion involves a difcuffion of the politics of both England and Scotland during one of the moft interefting periods of their hiftory, and touches the characters, not only of the two fovereigns, but of their minifters and ftatefmen, it muft then be regarded in the light of a moft important hiftorical inquiry, without which our knowledge of the hiftory of our own country muft be obfcure, confufed, and unfatisfactory. In addition to thefe motives of inquiry, this queftion has exercifed fome of the ableft heads both of earlier and of latter times; and it is no mean pleafure to engage in a conteft of genius and of talents, and to try our ftrength in the decifion of a controverfy which has been maintained on both fides with confummate ability.

As we have elfewhere (fee Mary, *Encycl.*) given an abftract of the arguments on both fides of this difputed queftion, it would be altogether improper to repeat them here; but juftice to the fubject of this memoir requires us to fay, that by his manner of difcuffing it he acquired high reputation in the republic of letters. Before the appearance of the Inquiry, fays an ingenious writer, it was the fafhion for literary difputants to attack each other like mifcreants and banditti. The *perfon* was never feparated from the *caufe*; and whatever attached the *one*, was confidered as equally affecting the *other*; fo that fcurrility and abufe bloated the pages even of a Bentley and a Ruddiman. The Hiftorical Inquiry was free from every thing of that fort: and though the higheft name produced not a mitigation of the force of any argument, the meaneft never fuffered the fmalleft abufe. He confidered it as being greatly beneath the dignity of a man contending for truth, to overftretch even an argument in the fmalleft degree, far more to pervert a fact to anfwer his purpofe, on any occafion. In the courfe of his argument, he had too often occafion to fhew that this had been done by others; but he difdained to imitate them. His reafoning was forcible and elegant; impartially fevere, but always polite, and becoming the gentleman and the fcholar.

When this book appeared, it was univerfally read in Britain, and very well tranflated into French, under the title of "Recherches Hiftoriques et Critiques fur les Principales Preuves d l'Accufation intentée contre Marie Reine d'Ecoffe." The intereft it excited among literary men may be judged of from the character of thofe by whom it was reviewed on its publication, in the periodical works of the time. Dr Douglas, now bifhop of Salifbury, Dr Samuel Johnfon, Dr John Campbell, and Dr Smollet—all wrote reviews of Mr Tytler's book, containing very particular accounts of its merits, and elaborate analyfes of the chain of its arguments. As an argument on evidence, no fuffrage could perhaps be more decifive of its merits than that of one of the greateft lawyers, and indeed one of the ableft men that ever fat on the woolfack of England, the late Lord Chancellor Hardwicke, who declared Mr Tytler's Inquiry to be the beft concatenation of circumftantiate proofs brought to bear upon one point that he had ever perufed. What effect that body of evidence, or the arguments deduced from it, ought to have upon the minds of thofe to whom the fubject may become matter of inveftigation, we do not prefume to determine. The opinion of the late Dr Henry, author of the Hiftory of Great Britain on a New Plan, may perhaps be thought neither partial nor confident. He fays, in a letter to Mr Tytler, publifhed in the firft volume of Tranfactions of the Antiquarian Society of Scotland. That he would be a bold man who fhould now publifh an hiftory of Queen Mary in the fame ftrain with the two hiftorians (Mr Hume and Dr Robertfon), whofe opinions on the fubject the Inquiry had examined and controverted.

The moft exceptionable part of Mary's conduct, which, though it may admit of an apology, cannot be vindicated,

vindicated, is her marriage to Bothwell; and for that marriage Mr Tytler made an apology, founded on facts, which he would be a daring or very bigotted man who would attempt to controvert. See the article already referred to.

Besides the *Historical Inquiry*, and the *Dissertation on the Marriage of Queen Mary with the Earl of Bothwell*, our author published several other works on historical and literary subjects; of which the first was, the *Poetical remains of James I. King of Scotland*, consisting of *the King's Quhair*, in six cantos, and *Christ's Kirk on the Green*; to which is prefixed a dissertation on the Life and Writings of King James, in one volume 8vo, printed at Edinburgh in 1783. This dissertation forms a valuable morsel of the literary history of Europe; for James ranked still higher in the literary world as a *poet*, than in the political world as a *prince* (A). Great justice is done to his memory in both respects in this dissertation: and the two morsels of poetry here rescued from oblivion will be esteemed by men of taste as long as the language in which they are written can be understood.

2. "A Dissertation on Scottish Music," first subjoined to Arnot's history of Edinburgh. The simple melodies of Scotland have been long the delight of the natives, many of which, to them, convey an idea of pathos that can be equalled by none other; and are much admired by every stranger of musical talents who has visited this country. They have a powerful effect, indeed, when properly introduced, as a relief, into a musical composition of complicated harmony. These are of two kinds, pathetic and humorous. Those who wish to receive information concerning this curious subject, will derive much satisfaction from the perusal of this dissertation. There is yet another kind of music peculiar to the Highlands of Scotland, of a more wild, irregular, and animating strain, which is but slightly treated here, and requires to be still more fully elucidated.

3. "Observations on the Vision, a poem," first published in Ramsay's Evergreen, now also printed in the Transactions of the Society of Antiquaries of Scotland. This may be considered as a part of the literary history of Scotland.

4. "On the Fashionable Amusements in Edinburgh during the last century," *ibid*. It is unnecessary to dwell on the light that such dissertations as these, when judiciously executed, throw upon the history of civil society and the progress of manners. Mr Tytler was likewise the author of N° 16. of the Lounger, a weekly paper, published at Edinburgh in the year 1786. His subject is the Defects of Modern Female Education in teaching the Duties of a Wife; and he treats that subject like a master.

On all Mr Tytler's compositions the character of the *man* is strongly impressed, which never, as in some other instances, is in the smallest degree contradicted by, or at variance with, the character of the *author*. He wrote what he felt, on subjects which he felt, on subjects relating to his native country, to the arts which he loved, to the times which he revered. His heart, indeed, was in every thing which he wrote, or said, or did. He had, as his family and friends could warmly attest, all the kindness of benevolence: he had its anger too; for benevolence is often the parent of anger. There was nothing neutral or indifferent about Mr Tytler. In philosophy and in history, he could not bear the coldness, or what some might call the temperance of scepticism; and what he firmly believed, it was his disposition keenly to urge.

His mind was strongly impressed by sentiments of religion. His piety was fervent and habitual. He believed in the doctrine of a particular Providence, superintending all the actions of individuals as well as the great operations of Nature: he had a constant impression of the power, the wisdom, and the benevolence of the Supreme Being; and he embraced, with thorough conviction, the truths of Christianity.

His reading was various and extensive. There was scarcely a subject of literature or taste, and few even of science, that had not at times engaged his attention. In history he was deeply versed; and what he had read his strong retentive memory enabled him easily to recal. Ancient as well as modern story was familiar to him; and, in particular, the British history, which he had read with the most minute and critical attention. Of this, besides what he has given to the public, a great number of notes, which he left in MS. touching many controverted points in English and Scottish history, afford the most ample proof.

In music as a science he was uncommonly skilled. It was his favourite amusement; and with that natural partiality which all entertain for their favourite objects, he was apt to assign to it a degree of moral importance which some might deem a little whimsical. He has often been heard to say, that he never knew a good taste in music associated with a malevolent heart: And being asked, What prescription he would recommend for attaining an old age as healthful and happy as his own? "My prescription (said he) is simple—short but cheerful meals, music, and a good conscience."

In domestic life, Mr Tytler's character was particularly amiable and praise worthy. He was one of the kindest husbands and most affectionate fathers. At the beginning of this account, we mentioned his having lost, at an advanced period of life, an excellent wife, and a son and a daughter both grown to maturity, who merited and possessed his warmest affections. The temper of mind with which he bore these losses, he has himself expressed in a MS. note, written not long before his death; with which, as it conveys a sentiment equally important in the consideration of this life, and in the contemplation of that which is to come, we shall conclude the present memoir: "The lenient hand of time (says he, after mentioning the death of his wife and children), the lenient hand of time, the affectionate care of my remaining children, and the duty which calls on my exertions for them, have by degrees restored me to myself. The memory of those dear objects gone before me, and the soothing hope that we shall soon meet again, is now the source of extreme pleasure to me. In my retired walks in the country I am never alone; those dear shades are my constant companions! Thus what I looked upon as a bitter calamity, is now become to me the chief pleasure in life."

U, V.

(A) There is a beautiful historical picture of this prince playing on the harp, with his queen and a circle of his courtiers listening to the music, by Graham, in London; one of the most eminent artists of the age.

U, V.

Vacuum
||
Vanda.

VACUUM Boyleanum, is the approach to a real vacuum, to which we can arrive by means of the air pump.

Torricellian Vacuum, is the most complete vacuum which we can make by means of the torricellian tube. See Barometer, and Pneumatics, *Encycl.*

VADE-mecum, the title given to such books as men of particular professions, having frequent occasion to consult, may easily carry about with them. Thus a small volume, published in the beginning of the 18th century, giving an account of the ancient and present church of England, and of the duties, rights, privileges, and hardships of the clergy, is known by the title of *the Clergyman's Vade mecum.*

VAKEEL, a minister agent, or ambassador.

VALGUS, *Bow* or *Bandy Legged.* Some children are bow legged from their birth; others become so from setting them on their feet too early. The tibia of some is crooked; the knees of others are distorted; from a fault in the ankle, the feet of some are turned inwards, these are called *vari;* and in others they turn outwards, these are called *valgi.* The best method of preventing these disorders in weakly children, is to exercise them duly, but not violently; by dancing or tossing them about in one's arms, and not setting them much on their feet, at least not without properly supporting them: if the disorder attends at the birth, or increases after it is begun, apply emollients, then apply boots of strong leather, wood, &c. as required to dispose the crooked legs gradually to a proper form: or other instruments may be used instead of boots, which, when not too costly, are usually to be preferred. Slighter instances of these disorders yield to careful nursing without instruments.

VANDA, the Indian name of a plant of the genus Epidendrum: which see, *Encycl.* The *vandà* is thus described by Sir William Jones.

"Cal. *Spathes* minute, straggling. Cor. *Petals* five, diverging, oval oblong, obtuse, wavy; the two lowest larger; the three highest equal, bent towards the nectary. *Nectary* central, rigid: *Mouth* gaping, oblique: *upper lip* shorter, three parted, with a polished honey-cup; *under lip* concave in the middle, keeled above, with two smaller cavities below, two processes at the *base* incurved, hollow, oval pointed, converging, honey-bearing. Stam. *Filaments* very short. *Anthers* round, flattish, margined, covered with a lid, easily deciduous from the *upper lip* of the nectary. Pist. *Germ.* beneath long, ribbed, contorted with curves of opposite flexure. *Style* very short, adhering to the *upper lip. Stigma* simple. Per. *Capsule* oblong conic, wreathed, six keeled, each with two smaller keels, three-celled, crowned with the dry corol. Seeds innumerable, like fine dust affixed to the *receptacle* with extremely fine hairs, which become thick wool. *Scapes* incurved, solitary, from the cavity of the leaf, at most seven flowered; pedicles alternate. *Petals* milk white externally, transparent; brown within, yellow-spotted. *Upper lip* of the nectary snow white, *under lip* rich purple, or light crimson, striated at the base, with a bright yellow gland, as it seems, on each process. The flowers gratefully fragrant, and exquisitely beautiful, looking as if composed of shells, or made of enamel; crisp elastic, viscid internally. *Leaves* sheathing, opposite, equally curved, rather fleshy, sword-form, retuse in two ways at the summit, with one acute point. *Roots* fibrous, smooth, flexible; shooting even from the top of the leaves."

Vandalia,
Vandermonde.

This lovely plant attaches itself chiefly to the highest *Amras* and *Bilvas* (the *Mangifera* and *Cratæva* of Lin.); but it is an air-plant, and lives (says the President) in a pot *without earth or water*: its leaves are excavated upwards, to catch and retain dew.

VANDALIA, a duchy of Farther Pomerania, subject to the king of Prussia. Stolpen is the capital.

Vandalia, a country in Germany, in the circle of Lower Saxony and duchy of Mecklenburg. It lies between the bishopric and duchy of Schwerin, the lordships of Stocrock and Stargard, Pomerania, and the marquisate of Brandenburg; and is 75 miles in length and 7 in breadth. It contains several small lakes, and the principal town is Gustrow.

VANDERMONDE, member of the National Institute of Sciences and Arts, was born at Paris in the year 1735. He devoted his youth to self-instruction; and even at the age of thirty was far enough from suspecting that he was destined to instruct others in his turn. Chance brought him near to the celebrated Fontaine. That sexagenary geometrician easily divined the progress which Vandermonde would one day make in the mathematics; in him he anticipated, as it were, a successor to himself; he patronised and caressed him, let him into the secret of his researches, calculations, inventions, of that lively enjoyment which profound speculation gives to an elevated attentive mind; and which, blended with the sweets of tranquillity, the charms of retreat, and the consciousness of success, becomes often a sort of passion, as felicitous as durable. All that time Fontaine, whose attention was again directed to the researches which he had added to those of Jean Bernoulli, relative to the then famous question *of the tautocrones*, had the glory to be vanquished only by D'Alembert and La Grange. Vandermonde, a witness to this combat, necessarily illustrious, animated by the honour which he saw annexed to that glorious defeat, enchanted with the sight of Fontaine, as happy, in spite of his age, from his love of geometry, as a youth of twenty could be with a sentiment less tranquil, thought he should insure his happiness for ever, by yielding to a passion which the ice of age could not extinguish; in a word, he devoted himself to geometry.

His labours, however, were for some time secret; and perhaps the public would never have enjoyed the benefit of any of his works, if another geometrician (whose name, says Lacepede, cannot be pronounced, in this place, without a mixture of interest and regret) had not inspired him with a consciousness of his own strength, and courage to display it. Fontaine had already devoted him to geometry; Dulejour exhorted him to penetrate even into its sanctuary. In brief, he presented himself

himſelf to the Academy of Sciences, into which he was admitted in 177 ; and in that very year juſtified the ſuffrages of his aſſociates, by a paper which he publiſhed relative to the reſolution of equations.

From the 16th century the method of reſolving equations of the four firſt degrees has been known, and ſince that time the general theory of equations has received great improvements. In ſpite, however, of the recent labours of many great geometricians, the ſolutions of equations of the fifth degree had in vain been attempted. Vandermonde wiſhed to conſolidate his labours with thoſe of other illuſtrious analyſts; and he propoſed a new theory of equations, in which he ſeems to have made it particularly his buſineſs to ſimplify the methods of calculation, and to contract the length of the *formulæ*, which he conſidered as one of the greateſt difficulties of the ſubject.

This work was quickly followed by another on the problems called by geometricians *problems of ſituation*. It ſeems to have been the deſtiny of Vandermonde, as well as of Fontaine, who firſt initiated him into the myſteries of mathematical ſcience. to labour frequently upon ſubjects already handled by the greateſt maſter. In his firſt memoir he had ſtarted, ſo to ſpeak, in competition with La Grange and Euler; in his ſecond, with Euler and Leibnitz. This laſt was of opinion that the analyſis made uſe of in his time, by the geometricians, was not applicable to all queſtions in the phyſical ſciences; and that a new geometry ſhould be invented, to calculate the relations of poſitions of different bodies, in ſpace: this he called *geometry of ſituation* *. Excepting, however, one application, made by Leibnitz himſelf, to the game of *ſolitaire*, and which, under the appearance of an object of curioſity, ſcarcely worthy the ſublimity and uſefulneſs of geometry, is an example for ſolving the moſt elevated and important queſtions, Euler was almoſt the only one who had practiſed this geometry of ſituation. He had reſorted to it for the ſolution of a problem called the *cavalier*, which alſo appeared very familiar at firſt ſight, and was alſo pregnant with uſeful and important applications. This problem, with the vulgar, conſiſted merely in running through all the caſes of the cheſs board, with the *knight* of the game of cheſs; to the profound geometrician, however, it was a precedent for tracing the route which every body muſt follow, whoſe courſe is ſubmitted to a known law, by conforming to certain required conditions, through all the points diſpoſed over a ſpace in a preſcribed order. Vandermonde was chiefly anxious to find in this ſpecies of analyſis a ſimple notation, likely to facilitate the making of calculations; and he gave an example of this, in a ſhort and eaſy ſolution of the ſame problem of the cavalier, which Euler had rendered famous.

His taſte for the high conceptions of the ſpeculative ſciences, as blended with that which the *Amor patriæ* naturally inſpires for objects immediately uſeful to ſociety, had led him to turn his thoughts towards perfecting the arts converſant in weaving, by indicating a manner of noting the points through which are to paſs the threads intended to form the lines which terminate the ſurface of different regular bodies: accordingly a great part of the above memoir is taken up with this ſubject.

In the year following (1772) he printed a third memoir; in which he traced out a new path for geometers, diſcovering, by learned analytical reſearches, *irrational* quantities of a new ſpecies, ſhewing the ſquares of which theſe *irrationals* are the terms of the ſum, and pointing out a direct and general method of making in them all the poſſible reductions. Va der-

In the ſame year appeared his work on the Elimination of unknown Quantities in Algebra. This elimination is the art of bringing back thoſe equations which include many unknown quantities, to equations which only contain one. The perfection of reſearches in this art would conſiſt in obtaining a general and particular *formula* of elimination in a form the moſt conciſe and convenient, in which the number of equations and their degrees ſhould be deſigned by indeterminate letters. Vandermonde, while he conſidered the geometers as very diſtant from this point, had ſome glimpſe of a poſſibility of reaching it, and propoſed ſome new methods of approaching nearer it.

In 1778, he preſented, in one of the public ſittings of the Academy, a new ſyſtem of harmony, which he detailed more fully in another public ſitting of 1780. In this ſyſtem, Vandermonde reduces the [illegible] of proceeding adopted until his time, to two principal rules, which thus become eſtabliſhed [illegible] all muſicians. Theſe two general rules, one on the ſucceſſion of according ſounds, the other on the arrangement of the parts, depend themſelves on a law more elevated, which according to Vandermonde, ought to rule the whole ſcience of harmony.

By the publication of this work, he ſatisfactorily attained the end he had propoſed to himſelf, and obtained the ſuffrages of three great men, repreſentatives, ſo to ſpeak, of the three great ſchools of Germany, France, and Italy; Gluck, Philidor, and Piccini.

With theſe labours, intermingled with frequent reſearches on the mechanic arts, as well as on objects of political economy. the attention of Vandermonde was taken up; when, July 14. 1789, the voice of liberty reſounded over the whole ſurface of France, and ſuddenly all the thoughts, as well as all the affections, of Vandermonde, were engaged on the ſide of what he called liberty.

He became ſo furious a democrate, ſo outrageous an enemy to every thing eſtabliſhed, that he concurred in the abolition of the Royal Academy, of which he had been ſo ambitious of becoming a member, and aſſociated himſelf cloſely with Robeſpierre, Marat, and the reſt of that atrocious gang of villains, who covered France with ruins, with ſcaffolds, and with blood. This part of Vandermonde's hiſtory is ſuppreſſed by his eulogiſt Lacepede, becauſe, forſooth, diſcuſſions on *political opinions* ought not, in his opinion, to be admitted into the ſanctuary of the ſciences.

In that ſanctuary he did not long remain. Soon after his atrocities, he was attacked by a diſorder in his lungs, which almoſt taking away his breath, manifeſted itſelf by alarming ſymptoms, and conducted him by rapid ſteps to the tomb. He died in the end of the year 1795; a ſtriking inſtance of the wayward violence of the human mind, which even the love of ſcience could not keep at a diſtance from tumult and uproar.

VARENIUS (Bernard), a learned Dutch geographer and phyſician of the 17th century, who was author of the beſt mathematical treatiſe on geography, intitled, *Geographia Univerſalis, in qua affectiones generales Telluris*

ris explicantur. This excellent work has been translated into all languages, and was honoured by an edition, with improvements, by Sir Isaac Newton, for the use of his academical students at Cambridge.

VARIABLE, in geometry and analytics, is a term applied by mathematicians to such quantities as are considered in a variable or changeable state, either increasing or decreasing. Thus the abscisses and ordinates of an ellipsis, or other curve line, are variable quantities; because these vary or change their magnitude together, the one at the same time with the other. But some quantities may be variable by themselves alone, or while those connected with them are constant: as the abscisses of a parallelogram, whose ordinates may be considered as all equal, and therefore constant; also the diameter of a circle, and the parameter of a conic section, are *constant*, while their abscisses are *variable*. See FLUXIONS, *Encycl.*

VARIATION OF CURVATURE, in geometry, is used for that inequality or change which takes place in the curvature of all curves except the circle, by which their curvature is more or less in different parts of them; and this variation constitutes the quality of the curvature of any line.

1 Variolæ vaccinæ long known in Gloucestershire,

VARIOLÆ VACCINÆ, or *Cow-pox*, is the name commonly, though, as some people think, improperly, given to a very singular disease, which, for two or three years past, has occupied a great share of the attention of medical men. It has been many years prevalent in some of the great dairy counties in England, particularly Gloucestershire; and it has been long understood by the farmers and others in these counties, that it for ever exempts all persons who have been infected with it from the contagion of small pox.

It is very surprising that, though they knew this fact, and although no person had ever been known to die of the cow pox, they never thought of having recourse to a voluntary infection of this kind, in order to free themselves and their families from the possibility of being infected with the variolous poison, which so often proves mortal. In one case, indeed, communicated to Dr Pearson by Mr Downe of Bridport, the experiment was long ago tried by a farmer upon his own person, and with complete success: But this only makes it the more wonderful that his example should not have been followed.

2 And in the duchy of Holstein.

In the town of Kiel, however, in the duchy of Holstein, where the disease is said to be well known, as frequently affecting cows, we are told that children are sometimes inoculated with cow-pox (*Die Finnen*), with a view to preserve their beauty; but that the people in the country do not like this inoculation, because they pretend that it leaves behind it several disorders.

3 Vaccine inoculation introduced by Dr Jenner.

With these exceptions, Dr Jenner was the first person who introduced the vaccine inoculation; and to him the public are also indebted for the first careful and accurate investigation of this interesting subject. The following is his account of the origin and history of the disease, and of its characteristic symptoms.

4 Origin of the disease, according to him.

"There is a disease to which the horse, from his state of domestication, is frequently subject. The farriers have termed it *the grease*. It is an inflammation and swelling in the heel, from which issues matter possessing properties of a very peculiar kind, which seems capable of generating a disease in the human body (after it has undergone the modification which I shall presently speak of), which bears so strong a resemblance to the small pox, that I think it highly probable that it may be the source of that disease.

"In this dairy county (Gloucestershire), a great number of cows are kept, and the office of milking is performed indiscriminately by men and maid servants. One of the former having been appointed to apply dressings to the heels of a horse affected with *the grease*, and not paying due attention to cleanliness, incautiously bears his part in milking the cows with some particles of the infectious matter adhering to his fingers. When this is the case, it commonly happens that a disease is communicated to the cows, and from the cows to the dairy maids, which spreads through the farm until most of the cattle and domestics feel its unpleasant consequences. This disease has obtained the name of the cow pox. It appears on the nipples of the cows in the form of irregular pustules. At their first appearance they are commonly of a palish blue, or rather of a colour somewhat approaching to livid, and are surrounded by an erysipelatous inflammation. These pustules, unless a timely remedy be applied, frequently degenerate into phagedenic ulcers, which prove extremely troublesome. The animals become indisposed, and the secretion of milk is much lessened. Inflamed spots now begin to appear on different parts of the hands of the domestics employed in milking, and sometimes on the wrists, which quickly run on to suppuration, first assuming the appearance of the small vesications produced by a burn. Most commonly they appear about the joints of the fingers, and at their extremities; but whatever parts are affected, if the situation will admit, these superficial suppurations put on a circular form, with their edges more elevated than their centre, and of a colour distantly approaching to blue. Absorption takes place, and tumors appear in each axilla. The system becomes affected, the pulse is quickened, and shiverings, with general lassitude, and pains about the loins and limbs, with vomiting, come on. The head is painful, and the patient is now and then even affected with delirium. These symptoms, varying in their degrees of violence, generally continue from one day to three or four, leaving ulcerated sores about the hands, which, from the sensibility of the parts, are very troublesome, and commonly heal slowly, frequently becoming phagedenic, like those from whence they sprung. The lips, nostrils, eyelids, and other parts of the body, are sometimes affected with sores; but these evidently arise from their being needlessly rubbed or scratched with the patient's infected fingers. No eruptions of the skin have followed the decline of the feverish symptoms in any instance that has come under my inspection, one only excepted; and in this case a very few appeared on the arms: they were very minute, of a vivid red colour, and soon died away without advancing to maturation; so that I cannot determine whether they had any connection with the preceding symptoms.

5 Its appearance on the cow and the person who milks her.

"Thus the disease makes its progress from the horse to the nipple of the cow, and from the cow to the human subject.

"Morbid matter of various kinds, when absorbed into the system, may produce effects in some degree similar; but what renders the cow-pox virus so extremely singular is, that the person who has been thus affected 6 Its singularity,

Variola Vaccinæ.

is for ever after secure from the infection of the small-pox; neither exposure to the variolous effluvia, nor the insertion of the matter into the skin, producing this distemper.

17 Though it sometimes confounded with another dis

'It is necessary to observe, that pustulous sores frequently appear spontaneously on the nipples of cows; and instances have occurred, though very rarely, of the hands of the servants employed in milking being affected with sores in consequence, and even of their feeling an indisposition from absorption. These pustules are of a much milder nature than those which arise from that contagion which constitutes the true cow-pox. They are always free from the bluish or livid tint so conspicuous in that disease. No erysipelas attends them, nor do they shew any phagedenic disposition, as in the other case, but quickly terminate in a scab, without creating any apparent disorder in the cow. This complaint appears at various seasons in the year, but most commonly in the spring, when the cows are first taken from their winter food and fed with grass. It is very apt to appear also when they are suckling their young. But this disease is not to be considered as similar in any respect to that of which I am treating, as it is incapable of producing any specific effects on the human constitution. However, it is of the greatest consequence to point it out here, lest the want of discrimination should occasion an idea of security from the infection of the small-pox, which might prove delusive."

Dr Jenner adds, that the active quality of the virus from the horse's heels is greatly increased after it has acted on the nipples of the cow, as it rarely happens that the horse affects his dresser with sores, and as rarely that a milkmaid escapes the infection when she milks infected cows. It is most active at the commencement of the disease, even before it has acquired a pus-like appearance. Indeed the Doctor is rather induced to think that the matter loses this property entirely as soon as it is secreted in the form of pus, and that it is the thin darkish looking fluid only, oozing from the newly formed cracks in the heels, similar to what sometimes exudes from erysipelatous blisters, which gives the disease. He is led to this opinion, from having often inserted pus taken from old sores in the heels of horses, into scratches made with a lancet, on the sound nipples of cows, which has produced no other effect than simple inflammation.

He is uncertain if the nipples of the cow are at all times susceptible of being acted upon by the virus from the horse, but rather suspects that they must be in a state of predisposition, in order to ensure the effect. But he thinks it is clear that when the cow pox virus is once generated, the cows, when milked with a hand really infected, cannot resist the contagion, in whatever state their nipples may chance to be. He is also doubtful whether the matter, either from the cow or the horse, will affect the sound skin of the human body; but thinks it probable that it will not, except on those parts where the cuticle is very thin, as on the lips.

At what period the cow-pox was first noticed in Gloucestershire is not upon record. The oldest farmers were not unacquainted with it in their earliest days when it appeared upon their farms, without any deviation from the phenomena which it now exhibits. Its connection with the small pox seems to have been unknown to them. Probably the general introduction of inoculation first occasioned the discovery. Dr Jenner conjectures that its rise in that neighbourhood may not have been of very remote date, as the practice of milking cows might formerly have been in the hands of women only; and consequently the cows might not in former times have been exposed to the contagious matter brought by the men servants from the heels of horses. He adds, that a knowledge of the source of the infection is new in the minds of most of the farmers, but has at length produced good consequences; and that it seems probable, from the precautions they are now disposed to adopt, that the appearance of the cow-pox in that quarter may either be entirely extinguished or become extremely rare.

"With respect to the opinion adduced (Dr Jenner observes), that the source of the infection is a peculiar morbid matter arising in the horse; although I have not (says he) been able to prove it from actual experiments conducted immediately under my own eye, yet the evidence I have adduced appears to establish it.

"They who are not in the habit of conducting experiments, may not be aware of the coincidence of circumstances, necessary for their being managed so as to prove perfectly decisive; nor how often men engaged in professional pursuits are liable to interruptions, which disappoint them almost at the instant of their being accomplished; however, I feel no room for hesitation respecting the common origin of the disease, being well convinced that it never appears among the cows, except it can be traced to a cow introduced among the general herd which has been previously infected, or to an infected servant, unless they have been milked by some one who, at the same time, has the care of a horse affected with diseased heels."

The following case, which we also quote from Dr Jenner, would seem to shew that not only the heels of the horse, but other parts of the body of that animal, are capable of generating the virus which produces the cow-pox.

"An extensive inflammation of the erysipelatous kind appeared, without any apparent cause, upon the upper part of the thigh of a sucking colt, the property of Mr Millet, a farmer at Rockhampton, a village near Berkeley. The inflammation continued several weeks, and at length terminated in the formation of three or four small abscesses. The inflamed parts were fomented, and dressings were applied by some of the same persons who were employed in milking the cows. The number of cows milked was twenty four, and the whole of them had the cow-pox. The milkers, consisting of the farmer's wife, a man, and a maid servant, were infected by the cows. The man-servant had previously gone through the small-pox, and felt but little of the cow-pox. The servant maid had some years before been infected with the cow-pox, and she also felt it now in a slight degree: but the farmer's wife, who never had gone through either of these diseases, felt its effects very severely. That the disease produced upon the cows by the colt, and from them conveyed to those who milked them, was the *true* and not the *spurious* cow-pox, there can be scarcely any room for suspicion; yet it would have been more completely satisfactory had the effects of variolous matter been ascertained on the farmer's wife; but there was a peculiarity in her situation which prevented my making the experiment."

Subsequent

Variola Vaccinæ.

Dr Jenner's opinion of the origin of the disease controverted.

Subsequent authors have not been all disposed to adopt Dr Jenner's opinion that this disease derives its origin from the grease in horses. We have seen the Doctor himself allow that he has not been able to prove it decisively by actual experiments; and to establish a fact so contrary to all analogy, perhaps no weaker evidence ought to be admitted. The only other bestial disorder with which we are acquainted, which is capable of being communicated by contagion to the human species, is hydrophobia: but here the disorder is the same in man as in the animal from which he derives it; and the analogy holds good in the propagation of the vaccine disease from the cow to her milker. But that the discharge from a local disease in the heel of a horse should be capable of producing a general disorder in the constitution of a cow, with symptoms totally different, and that this new disease once produced should be capable of maintaining an uniform character in the cow and in man, seems a much greater departure from the ordinary proceedings of Nature. We are very far from saying that this is impossible; for little indeed do we know of what Nature can or cannot do. All we mean to say is, that a fact so very extraordinary ought not to be hastily admitted.

In Holstein, we are told that the farmers do not know of any relation existing between the grease and the cow pox, at least a person who resided three years in that country never heard of any. This, however, is certainly no proof. The same communication which contains this remark (a letter from Dr De Carro of Vienna to Dr G. Pearson) adds, "that in great farms men do not milk cows, but that in the smaller ones that happens very often; that a disease of horses, called *mauke* (true German name for *grease*), is known by all those who take care of them; that old horses particularly, attacked with the mauke, are always put in cow's stables, and there are attended by women; and that it is particularly in harvest that men in small farms milk cows." It must be allowed, then, that in this situation, supposing Doctor Jenner's opinion well founded, the cow-pox was naturally to be looked for, and here accordingly we find it. The question is certainly of no real utility, and therefore it has very properly been less attended to than other points respecting this disorder which lead to important practical conclusions.

Of all the questions which have arisen relative to the cow pox, there is none so interesting, and luckily there is none which has received so full a discussion, or so satisfactory an answer, as the one we are now about to consider. Are those persons who have once had the cow-pox effectually and for ever secured against the variolous contagion?

9
A previous attack of this disease renders the body unsusceptible of small-pox.

Dr Jenner, in his first publication, was decidedly of opinion that a previous attack of this disorder rendered the human body for ever unsusceptible of the variolous virus; and besides the universal popular belief in the countries where cow-pox is known, he brought forward a number of cases in support of his assertion. By some of these it appeared that persons who had been affected with the cow-pox above twenty or thirty years before, continued secure against infection, either by the effluvia from patients under small-pox, or by inoculation. But along with this opinion he entertained other two, which, to many people, appeared so surprising as to take away all credit from the former. The first was, that a previous attack of small-pox did not prevent a subsequent attack of cow pox; and the second was perhaps still more wonderful, that the cow pox virus, although it rendered the constitution unsusceptible of the small pox, should nevertheless leave it unchanged with respect to its own action, for that the same person is susceptible of repeated attacks of the cow-pox.

These opinions have been submitted to the test of very extensive experience by a variety of intelligent practitioners; and we think there can now be little doubt that the two last are erroneous, while the truth of the first has been established by an immense body of incontrovertible evidence.

The opinions that a person who has had the small-pox may afterwards have the cow pox, and that the same person may have the cow pox more than once, probably arose from the distinction between the local effects of the vaccine virus, and the general disorder of the constitution not having been sufficiently attended to. It is generally admitted, that in the inoculated small-pox the local affection may go so far as that a pustule shall arise on the part, containing matter capable of communicating the true small-pox to others, and yet, if no general affection of the constitution takes place, the patient is not secure from the disorder. In like manner, there are cases upon record which prove that a person may, after having had the small pox, have a local affection produced by inoculation, in which true variolous matter shall be formed capable of communicating both the local and constitutional symptoms of small-pox to others; and nurses, when much exposed to variolous contagion, often have an eruption resembling small-pox upon such parts of their skin as have been exposed to the action of the virus, though they have formerly undergone the disease. Yet there is probably no person at this day who will go so far as to assert that the same person can have the specific variolous fever more than once.

The case seems to be precisely the same with respect to cow-pox. Doctor Pearson and others have inoculated a number of persons after they have had the small-pox with the vaccine virus, and have produced only the local affection; and by the same test it is ascertained that the same person cannot more than once have the constitutional symptoms of the cow-pox. Dr Woodville indeed tells us that he has seen one case of genuine cow-pox pustule and specific fever in a constitution which had previously suffered the small-pox. There can be no higher authority on this subject than that of Dr Woodville; and if he had actually seen his patient in the small pox as well as the cow pox, we should have admitted this single case as completely decisive of the question. But the only evidence of this person having had the small-pox, is the assertion of the patient that he had it *when a child*. This we can by no means sustain as conclusive in opposition to the Doctor's own experience, as well as the experience of Dr Pearson.

That the milkers are subject to repeated attacks of, the local symptoms of cow pox, whether they have had the small-pox or not, is certain. In the case of the farmer's servants at Rockhampton, which we have quoted above from Dr Jenner, one of whom had previously undergone the small pox, and the other the cow-pox, and both of whom were afterwards infected by

Variolæ Vaccinæ. by the cow-pox *in a slight degree*, it seems reasonable to conclude that the local symptoms only were present in the last attack. We may at the same time observe, that in a case of this kind, where a very painful ulcer is produced in a very sensible part, this may probably be attended by an increased frequency of pulse; yet if this has not the specific marks of the cow pox fever, we should not say that such a person has the disorder constitutionally.

11 Success of vaccine inoculation. With respect to the principal proposition, that the specific fever of cow-pox renders the constitution unsusceptible of the variolous fever, we think no doubt now remains. Above 1000 persons who have undergone the vaccine inoculation have been afterwards inoculated with variolous matter, which has produced no other than local effects. Besides these, there have been a vast number inoculated by private practitioners in different parts of the kingdom, the result of which has not been reported. But we may safely suppose, that if any one of them had afforded a conclusion opposite to the one now generally admitted, it would have been communicated to the public.

We must not, however, conceal one seemingly well authenticated case which has lately occurred, and which, so far as it goes, certainly militates against this conclusion, and which, we doubt not, will be eagerly caught at by the opponents of the new practice. We quote it from the Medical and Chirurgical Review for September 1800.

12 A seemingly well authenticated exception. "Mr Malim, surgeon of Carey Street, London, inoculated a child, two years and an half old with vaccine matter procured from Dr Jenner. On the third day there were sufficient marks of the action of the virus, and from this time to the end of the disease the local affection proceeded regularly and without interruption. On the eighth day the child complained of headache and sickness; had a quick pulse, white tongue, and increased heat, with an enlargement and tenderness in the axilla. These symptoms subsided in the course of the next day, and the child remained well till the twelfth, when it had a very severe attack of fever, succeeded, the following day, by an irruption; the appearance, progress, and termination of which, left no doubt in the minds of several eminent practitioners of its being the small-pox. That it was really so, has been since clearly proved by inoculation. There was a child ill of small pox in the house at the time the above inoculation of cow-pox was performed."

The Reviewers justly remark, that the history is defective in not describing more minutely the appearances of the inoculated parts at the different stages, as well as in not mentioning the length of time that the matter had been taken previous to being used. Both these points are the more important, as a suspicion naturally arises, that the local affection which succeeded the vaccine inoculation was not the genuine cow-pox pustule, but one of the spurious kind, which had not the power of destroying variolous susceptibility. The matter having been furnished by Dr Jenner, no doubt, renders this supposition the less probable; but if it was either long or improperly kept after it came out of his hands, it may have undergone a material change, by putrefaction or otherwise. Dr Jenner mentions an instance of a practitioner, who had been accustomed to preserve variolous matter in a warm pocket; a situation favourable for producing putrefaction in it. This matter, when inserted, was found to produce inflammation, swellings of the axillary glands, fever, and sometimes eruptions; but not of the true variolous kind, as patients thus inoculated were found still susceptible of the small-pox contagion. It is surely a possible supposition, tho' merely a conjecture, that the vaccine matter in Mr Malim's case had undergone some such change.

The case however, is in several respects an interesting one. As it has been supposed that variolous contagion, communicated in the form of exhalation does not affect the constitution in less than fourteen or fifteen days, and as the vaccine matter, communicated by inoculation, produces its specific effects some days earlier, it has been suggested, that wherever a person has been accidentally exposed to variolous effluvia, we should endeavour to anticipate the small-pox by immediately inoculating with the vaccine virus. But if there be nothing falacious in the above case, it appears that this measure would not stop the progress of the small pox, but that our patient would incur the additional danger of having two diseases instead of one.

At all events, it must be allowed that this child had been infected by the small-pox before the vaccine matter had begun to produce its specific effects, and probably even before the inoculation. Thus the small-pox may be considered as having begun before the cow-pox; and though we should be forced to allow that, matters being thus situated, the latter disorder could not prevent the farther progress of the former, it by no means follows, that when the cow pox has fairly run its course, the constitution is still susceptible of small-pox. The two diseases must have existed in this patient at the same time, though the one was in a latent state during the active stage of the other. 13 Probably accounted for.

This solitary case, then, is by no means conclusive, and certainly is not sufficient to outweigh the immense mass of concurring evidence which is opposed to it.

We proceed now to another highly important branch of our subject—the comparison of the advantages and disadvantages of the two diseases, with a view to the practice of inoculation. 14 Advantages of the practice.

Notwithstanding the immense number of cases in which the inoculation of the cow-pox has been tried, we are not yet fully qualified to appreciate the value of the new practice; because the disease has varied very much in severity, and even in its most remarkable symptoms, and that without any cause which has yet been discovered.

Dr Jenner's account of the disease gave us reason to think that the local affection in cow-pox was more severe than in the inoculated small-pox: That the fever in this disease was never attended with dangerous symptoms: that those symptoms which affect the patient with severity are entirely secondary, excited by the irritating processes of inflammation and ulceration: that the disease was not attended with any eruption resembling small-pox: and that the sore produced by the inoculation was apt to degenerate into a very distressing phagedenic ulcer, which required to be treated with applications of a caustic nature, of which he found the unguentum hydrargyri nitrati the most useful.

Soon after Dr Jenner's publication, the attention of medical men was forcibly drawn to the subject; and several eminent practitioners in London, particularly Dr George

Variolæ Vaccinæ.

George Pearson, and Dr Woodville physician to the small-pox and inoculation hospitals, immediately began to practise the vaccine inoculation. The latter gentleman soon published an accurate and candid account of the effect of this virus upon 200 patients, with a table of the results of above 500 cases in which the inoculation was performed.

15
Anomalies in the progress of the disease.

It is very remarkable, that in none of these cases did the inoculated part ulcerate in the manner described by Dr Jenner, nor did the inflammation ever occasion any inconvenience, excepting in one instance, in which it was soon subdued by the aqua lythargyri acetati. The general affection of the constitution, on the other hand, though in a great majority of cases it was very slight, yet, in some instances, was severe. An eruption, exactly resembling small-pox, was, contrary to expectation, a very common occurrence, and in some the pustules were not fewer than 1000; and although in these cases the disease was still unattended with secondary fever, yet the febrile symptoms which took place from the commencement were considerable, and even alarming, as sometimes also happens with the inoculated small-pox.

Dr Woodville sometimes inoculated with matter from the primary sore in the arm, and sometimes with matter taken from the pustular eruption; and it appears from the table that a much larger proportion of those who were inoculated in the latter way had pustules, than of those who were inoculated either with matter immediately from the cow, or from the primary sore in the human body. There were 447 patients in all inoculated, either from the cow or from the primary sore; and of these 241 had pustules, and 206 had none. Sixty-two persons, on the other hand, were inoculated with matter from the pustules of ten different patients; and of these no fewer than 57 had pustules, and only 5 escaped without. Nor can it be said that this disproportion arose from these 10 patients having the disease in a more virulent form than ordinary, for matter was also taken from the primary sore in 4 of the 10, with which 48 were inoculated; of whom 27 had pustules, and 21 had none: whereas, of 9 persons who were inoculated with matter from the pustules of these same 4, only 2 escaped without pustules. This observation corresponds also with Dr Pearson's experience.

Although these eruptions have been met with by other practitioners, yet they certainly appear very rarely in private practice. Dr Woodville, for this reason, considers them, in a more recent publication, as the effect of some adventitious cause, independent of the cow-pox: And this he supposes to be the variolated atmosphere of the hospital, which those patients were necessarily obliged to inspire during the progress of the cow-pox infection. This opinion, however, does not seem to agree well with his former remark, which, as we have said, is confirmed by Dr Pearson, that eruptions rarely took place, if care was taken to avoid matter for inoculation from such as had pustules; a fact that cannot be explained on such a supposition. Neither is this idea reconcileable with what he also tells us, that the proportion of cases in the hospital attended with pustules has been of late only three or four in a hundred.

This change in the appearances of the disease in the hands of different practitioners, and even of the same practitioner at different times, is one of the most unaccountable circumstances respecting this singular disorder. There is some curious information on this subject, contained in a letter from Mr Stromeyer of Hanover to Mr Hannehmaun.

"This year (says he) we have inoculated 40 persons, as well with the vaccine matter received of Dr Pearson as with that from Dr Jenner; all of whom underwent the disease properly.

"Betwixt the London and Gloucester vaccine matter, it appears to me there subsists an essential difference. The London matter produces frequently an eruption of small pimples; but they disappear within a day or two at farthest. Dr Pearson calls these eruptions *pustules*.—The Gloucester matter has never produced this effect here; but *frequently occasioned ulcerations of the inoculated part, of a tedious and long duration; which the latter never did:* on account of which I now only make use of Dr Pearson's vaccine matter. The nettle-fever-like eruptions I have observed several times, but never that sort of eruption, repeatedly noticed in London, which so much resembles the small pox."

If these observations of Mr Stromeyer should be confirmed by the experience of others, they would go far to explain the difference which the London practitioners have found in this disease from the account given of it by Dr Jenner, notwithstanding the absence of the eruption resembling small-pox at Hanover. We believe an interchange of vaccine matter has once or twice taken place between London and Gloucestershire. Is it since that period that the eruption has been less frequent at London? Dr Pearson is inclined to suppose, that the comparative severity of the disease at London, during the first winter, arose rather from the difference in the human constitution at the different seasons of the year, than from any change in the state of the vaccine matter.

16
Mortality for the old practice over-rated by the advocates for the new.

In comparing the degree of danger from the inoculation of cow-pox with that arising from the inoculated small-pox, we are convinced that Dr Pearson greatly over-rates the mortality in the latter disorder. He supposes it to be no less than one in 200. Dr Moseley, on the other hand, who is a violent opponent of the vaccine inoculation, asserts, that he has inoculated several thousands with variolous matter, in Europe and the West Indies, without ever losing a patient, and that several other persons, whom he knows, have done the same, with the same success. We are afraid, however, that the experience of other inoculators does not afford so favourable a result. We believe that in this country the mortality is often occasioned by improper treatment; and from comparing the accounts which we have received from practitioners of extensive experience, and undoubted veracity, we believe that, where the treatment is proper from the beginning, the symptoms very rarely arise to an alarming height, and that the mortality is not so great as one in 600. And this estimate nearly corresponds with Dr Woodville's very great experience. It must be allowed, that patients in an hospital are subject to some disadvantages, which may be avoided in private practice; yet, out of the last 5000 cases of variolous inoculation at the inoculation hospital, prior to the publication of the Doctor's reports, the mortality did not exceed one in 600.

Notwithstanding this statement, however, we are happy

py to ſay, that the danger in the vaccine diſeaſe is ſtill much leſs. Dr Pearſon tells us, that in little more than ſix months after the new inoculation was introduced into London, which includes the period at which the cow-pox aſſumed the moſt unfavourable appearance, 2000 perſons at leaſt underwent the operation; of theſe, one only, an infant at the breaſt, under the care of Dr Woodville, died. In this ſolitary fatal caſe, the local tumor was but very inconſiderable; and the eruptive ſymptoms took place on the ſeventh day, when the child was attacked with fits of the ſpaſmodic kind, which recurred at ſhort intervals, with increaſed violence, and carried it off on the eleventh day after the cow-pox matter had been inſected into its arm, and after an eruption of about 80 puſtules had appeared.

17 Great ſucceſs of the new inoculation.

Since that time a much greater number, amounting certainly to ſeveral thouſands, have been inoculated with cow pox in different parts of Great Britain and on the continent. Among theſe, not one fatal inſtance, that we have heard of, has occurred.

But even if the danger to the individual from the ſmall-pox and from the cow-pox were equal, there is an important advantage to the public attending the latter, which we think would alone be ſufficient to intitle it to a preference—It is not capable of being propagated by the effluvia ariſing from the bodies of perſons infected with it. There are many ſituations in which a prudent ſurgeon will be reſtrained from inoculating with ſmall pox, leſt the contagion ſhould ſpread to other people, who may be either prevented by prejudice from ſubmitting to the operation, or in whom it would be obviouſly improper, from the circumſtances of age, teething, or the preſence of ſome other diſeaſe. Here the cow-pox virus may be ſubſtituted with great propriety. It is chiefly from this quality that the cow pox bids fair to extirpate the ſmall-pox entirely.

This valuable property of the vaccine diſorder is not, however, to be admitted without ſome limitation. When it produces numerous puſtules on the body, Dr Woodville tells us, that the exhalations they ſend forth are capable of affecting others, in the ſame manner as the ſmall-pox. Two inſtances of caſual infection in this way have fallen under his obſervation. In one, the diſeaſe was ſevere, and the eruption confluent; in the other, the diſeaſe was mild, and the puſtules few. It has been remarked, that the inoculated cow-pox is little, if at all, different from the diſeaſe when caſually caught. But, ſtrictly ſpeaking, the above are the only two caſes in which the diſeaſe has been communicated otherwiſe than by inoculation.

18 Whether the cow-pox and ſmall-pox ought to be conſidered as different diſeaſes.

The writers upon this ſubject are divided in opinion, whether the cow-pox and ſmall-pox ought to be conſidered as different diſeaſes, or whether they are merely varieties of the ſame diſeaſe.

They certainly, notwithſtanding the ſtrong analogy which ſubſiſts between them, differ from each other in ſeveral ſtriking particulars. The cow pox comes to man from the cow, and is capable of being carried back from him to that animal. Similar attempts with variolous matter have failed: in this reſpect, then, theſe two morbid poiſons are altogether different.

The local tumor produced by the inoculation of the cow-pox is commonly of a different appearance from that which is the conſequence of inoculation with variolous matter: for if the inoculation of the cow pox be performed by a ſimple puncture, the conſequent tumor, in the proportion of three times out of four, according to Dr Woodville, aſſumes a form completely circular, and it continues circumſcribed, with its edges elevated and well defined, and its ſurface flat, through every ſtage of the diſeaſe; while that which is produced from the variolous matter, either preſerves a peculiar form, or ſpreads along the ſkin, and becomes angulated, or irregular, or diſfigured by numerous veſiculæ. Another diſtinction ſtill more deciſive and general, is to be drawn from the contents of the cow pox tumor; for the fluid here formed very rarely becomes puriform; and the ſcab which ſucceeds is of a harder texture, exhibits a ſmoother ſurface, and differs in its colour from that which is formed by the concretion of pus. The appearances, however, are ſometimes ſo changed, that they can in no reſpect be diſtinguiſhed from thoſe which ariſe from the inoculation of ſmall-pox. We may alſo mention that the tendency of the ſore in the inoculated part to degenerate into a phagedenic ulcer does not occur in ſmall pox.

On the other hand, the points in which theſe two diſeaſes reſemble each other are very remarkable. When introduced into the body by inoculation, they affect the conſtitution in nearly the ſame length of time, and ſeem to be governed by nearly the ſame laws. They mutually deſtroy the ſuſceptibility of the body for the action of each other

Dr Pearſon, who thinks the diſeaſes ought to be conſidered as diſtinct ſpecies, nevertheleſs draws the following concluſions, as eſtabliſhed by experience.

"That in certain conſtitutions, or under the circumſtances of certain co operating agents, *the vaccine poiſon produces a diſeaſe reſembling the ſmall pox*; and of courſe the puſtule in the inoculated part is *very different from that of the vaccine pox ordinarily occurring*, and the eruptions *reſemble very much, if not exactly, ſome varieties of the ſmall-pox*: That in ſome inſtances theſe eruptions have occurred, although the inoculated part exhibited the genuine vaccine puſtule: That the matter of ſuch eruptive caſes, whether taken from the inoculated part, or from other parts, produces univerſally (A), or at leaſt generally, ſimilar eruptive caſes; and has not (he believes) been ſeen to go back, by paſſing through different conſtitutions, to the ſtate in which it produces what is called the *genuine vaccine diſeaſe*: That eruptions, of a different appearance from variolous ones, ſometimes occur in the true cow pox."

19 They are probably only varieties of the ſame diſeaſe.

From theſe facts we are ſtrongly inclined to think that the vaccine diſeaſe and the ſmall-pox ought merely to be conſidered as varieties of the ſame diſeaſe; and we have little doubt that they both derive their origin from the ſame ſource.

If Dr Jenner's opinion, that the vaccine diſeaſe is derived from *the greaſe*, were fully eſtabliſhed, we ſhould be diſpoſed to offer a conjecture, that the *ſmall-pox*, in coming from the horſe to man, may have paſſed thro' ſome

(A) We have ſeen that Dr Woodville's table contains a few exceptions to this rule, though it ſtrongly confirms the general truth of the propoſition.

some animal different from the cow, and may thus have undergone a modification similar to, but not exactly, the same with what takes place in the passage of the virus through the constitution of the cow.

But without having recourse to this conjecture, which is perfectly gratuitous, we are of opinion that the variations which have taken place in the cow pox within the last three years are sufficient to warrant a belief, that the small-pox may have originally been exactly the same disease, even in the human constitution, as the cow-pox is now; but that in a succession of ages, and from the operation of causes wholly unknown to us, it may have been changed to what we now see it.

We shall now conclude this article with a few practical remarks, which we hope may be of use to practitioners who mean to begin the vaccine inoculation.

20 Practical remarks.

It is of the utmost consequence that the matter employed should be the genuine vaccine virus. Dr Jenner points out the following particulars as sources of a spurious cow-pox: 1. That arising from pustules on the nipples or udder of the cow, which pustules contain no specific virus. 2. From matter, although originally possessing the specific virus, which has suffered a decomposition, either from putrefaction, or any other cause less obvious to the senses. 3. From matter taken from an ulcer in an advanced stage, though the ulcer arose from a true cow-pox. 4. From matter produced on the human skin from the contact of some peculiar morbid matter generated by a horse.

Many have remarked that inoculation with the vaccine matter is more apt to fail in communicating the infection than with variolous matter, especially if it be suffered to dry upon the lancet before it is used. This does not seem to depend upon the virus of the former being more volatile, but upon its becoming more hard and indissoluble upon exsiccation. Care should therefore be taken to moisten it a considerable time before it is used.

We have already noticed the danger that may arise from mistaking the local effects of the vaccine disease for its effects upon the constitution. To guard practitioners against this error, Dr Woodville makes the following remarks: " When a considerable tumor and an extensive redness take place at the inoculated part, within two or three days after the infectious matter has been applied, the failure of inoculation may be considered as certain as where neither redness nor tumor is the consequence. This rapid and premature advancement of the inflammation will always be sufficient to prevent the inoculator from mistaking such cases for those of efficient inoculation. But there are other circumstances under which I have found the inoculation to be equally ineffectual, and which, as being more likely to deceive the inoculator, require his utmost circumspection and discrimination. I here allude to cases in which it happens that though the local affection does not exhibit much more inflammation than is usual, yet neither vesicle nor pustule supervenes; and in which, about the sixth or seventh day, it rapidly advances into an irregular suppuration, producing a festering or crustaceous sore. Care, however, should be taken to distinguish this case from that in which the inoculated part assumes a pustular form, though it continues for one or two days only, when the same appearances follow as those above described; for I have experienced the latter inoculation to be as effectual as where the tumor has proceeded in the most regular manner."

" The efflorescence at the inoculated part, which seldom intervenes before the eighth, or later than the eleventh, day, is to be regarded as an indication that the whole system is affected; and if the patient has not felt any indisposition on or before its approach, he may be assured that there will not be any afterwards. When efflorescence does not commence till the eleventh day, it is almost always attended with more indisposition than when it occurs on the eighth or ninth day. The efflorescence is more frequent in young infants than in children advanced to three or four years of age; and the former have the efflorescence and the disease more favourably than the latter, insomuch that by far the greater part of them have no perceptible illness, and require no medicines. On the other hand, in adults, the cow-pox frequently produces headache, pain of the limbs, and other febrile symptoms, for two or three days, which are greatly relieved by a brisk purgative."

We would, upon the whole, recommend the vaccine inoculation to our medical readers as being an effectual preventative against the small-pox, and safer to the individual, while it is more advantageous to the public at large, in being less capable of propagation by contagion.

VECTOR, or RADIUS VECTOR, in astronomy, is a line supposed to be drawn from any planet, moving round a centre, or the focus of an ellipse, to that centre or focus. It is so called, because it is that line by which the planet seems to be carried round its centre; and with which it describes areas proportional to the times.

VEGETABLES. } See *Vegetable* SUBSTANCES in
VEGETATION. } this *Suppl.*

VENTILATION OF SHIPS is a matter of so great importance, that we would rather hazard the stating of an idle project for this purpose, than omit any thing which may be useful. We hazard nothing, however, in stating the following plan by Mr Abernethy, who candidly acknowledges that it is built upon the principles which we, together with the learned editor of Chambers's Cyclopædia, have borrowed from Dr Hailes. This plan consists merely in causing two tubes to descend from above the deck to the bottom of a vessel, or as low as ventilation is required; and which should communicate by smaller pipes (open at their extremities) with those places designed to be ventilated. There should be a contrivance for stopping these communicating pipes, so that ventilation may be occasionally prevented from taking place, or confined to any particular part of the vessel.

One of the principal air tubes should descend as near to the stern of the vessel as convenient, and the other as near to the stem.

Through that tube which is in the head, the foul air is to be extracted; and through that which is in the stern, the fresh air is to descend to the different decks and other apartments of the vessel.

The extraction of the air is easily effected in the following manner: Let a transverse tube be fitted to that which descends in the head of the vessel; it may be sunk within the level of the deck, so as to cause no inequality of surface. Let it be continued till it comes beneath

neath the fire-place, then ascend in a perpendicular direction through the fire, and open a little above it; or it may be made to communicate with the chimney. It would be more convenient if the fire was near the place where the tube rises through the deck; but the experiment must equally succeed, if the tube be made to descend again till it is beneath the common fire-place. The effect that will result from this contrivance is obvious; when the tube which passes through the fire is heated, the air will ascend with a force proportionable to its levity, and the ascending column can only be supplied from below, consequently it must come from all those parts of the ship with which the main tube communicates.

When the ports are open, the quantity of air thus exhausted from the ship will be supplied from all quarters; but if they were all shut, and the hatchways and other openings completely closed, the renewal of fresh air is made certain by means of the tube which descends in the stern. The main air tube, where it rises above the deck in the stern, should have an horizontal one fitted to it, which might be made to traverse, so that it could be turned to windward; it might also expand at its extremity like the mouth of a trumpet; and thus perfectly fresh air must enter, and the force of the gale would tend to impel it into the vessel.

When that part of the tube which passes through the fire is red hot, the draught which would be thus occasioned might perhaps be too great, and the open pipes which communicate with the decks might emit and imbibe the fresh air in so direct a stream, that it might be injurious to those persons within the current.

Mr Abernethy therefore thinks it would be better if those smaller pipes which lead from the main tubes were made to run along the decks, and communicate with them by numerous orifices. Two pipes opening into the main exhausting tube might be extended along the tops of the deck, in the angle formed between the sides and the cieling: and thus the air would be extracted equally from all parts, and in a manner not likely to occasion injurious currents. Some division of the stream of air which enters from the stern might also be made, if it were thought necessary.

Thus a very complete, and in no way injurious, ventilation may be obtained: the air in the vessel would be perfectly changed when the fire was strong, without expence or trouble; and a gradual and salubrious alteration of it might at all times be made, by a very little additional quantity of fuel. The air tubes should consist of separate joints, so that occasionally they might be taken to pieces; and to prevent their being injured or put out of order by rough usage, the copper pipes should be made of considerable strength, placed against the sides of the vessel, and even incased in wood.

In the Letters and Papers of the Bath Society, &c. we have the following description of a ventilator for preserving corn on ship board, by Thomas South, Esq;

Plate XLVII. Fig. 1. is a cylindrical air-vessel, or forcing pump, of lead, tin, or other cheap metal; its internal diameter being ten inches, and its length three feet; having a crutch-handled piston to work with, and an iron nosle, *viz.* a hollow inverted cone, two feet long, to condense the air, and increase its power in its passage downwards. This cylinder should be rivetted or screwed, by means of an iron collar or straps, to the deck it passes through, both above and below, as at *a a*; and should be farther secured by some holdfast near *b*, to keep it steady in working.

Fig. 2. is a bottom of wood, four inches and a half thick, with a projecting rim at its base, for the metal cylinder to rest on when cemented and screwed to the wood. The centre of this bottom is excavated, for the reception of the crown of the nosle. In the same figure the nosle is represented with its crown like a bowl dish, to condense the air gradually, without resistance, in its advance to the more contracted base of the inverted cone, *i. e.* the top or entrance of the nosle. About two-thirds down this nosle may be fixed a male screw, as *c c*, for the purpose hereafter mentioned.

N. B. The forcing-pump should be cased in wood, to protect it from outward bruises, which would prevent the working of the piston, and ruin its effects. The leather round the embolus should be greased when used.

Fig. 3. is a crutch-handle, fastened to the embolus A by its iron legs B, B. A is a cylinder of wood, cased with leather, so as to fit well, but glide smoothly, in the metal cylinder; having an opening as large as its strength will permit, for the free access of atmospheric air. C is a valve well leathered on its top, and yielding downwards to the pressure of the air when the piston is raised up. D is a cross bar of iron, to confine the valve, so that it may close instantly on the return of the piston downwards.

Fig. 4. is a tin pipe or tube, of less than four inches diameter, and of such length as, when fixed to the base of the cylinder, fig. 1. shall admit the nosle *d*, fig. 2. to within half an inch of the valve E, at the bottom of the wooden cylinder F, in fig. 4; which valve E will then yield to the pressure of air condensed in its passage through the nosle, and deliver it into the pipes below. This valve must be well leathered on its upper surface, and fastened with an hinge of leather to the cylinder it is meant to close: affixed to its bottom is the spindle G, passing through a spiral spring H, which, being compressed on the descent of the valve, will, by its elasticity, cause it to rise again, close the aperture above, and retain the air delivered beneath it. On connecting this cylinder with the upper end of the nosle, at *c c*, fig. 2. we must carefully prevent any lapse of air that way, by a bandage of oakum smeared with wax, on which to screw the cylinder, like the joints of a flute, air-tight. I is a bar of iron, having a rising in its centre, wide enough for the spindle to play through, but at the same time sufficiently contracted to prevent the passage of the spiral spring.

Fig. 5. is an assemblage of tin pipes, of any lengths, shaped suitably and conveniently to their situation in the ship, to the form of which, when shut into one another, they must be adapted; observing only, that the neck be straight for a length sufficient to admit the lower end of the cylinder, fig. 4. as high as the letter F, or higher.

Fig. 6. To the middle pipe, which runs along the bottom, should be fixed a perpendicular one, fully perforated, to convey the air more readily into the centre of the heap; and this may have a conical top, as represented in the Plate, perforated with a smaller punch to prevent the air from escaping too hastily. In large cargoes, two or three of these perpendiculars may be necessary;

Ventilation, Verden.

necessary; and each should be well secured by an iron bar *g*, screwed down to prevent their being injured by the shifting of the cargo in stormy weather or a rolling sea. The top of the conical cap of these pipes may reach two-thirds up the cargo.

Fig 7. is a valve of the same construction as that represented in fig. 4. but inclosed in a tube of brass, having a female screw at *ff*, adapted to the male screw *ee*, on the nosle fig 2. and may then be inserted into the head of the pipe fig. 5 This will add to the expence; but in a large apparatus is to be preferred, as a more certain security from lapse of air, than the junction of the tube fig. 4. to the neck *ee* in fig. 2.

N. B. *ee* is a neck of wood, making a part of the bottom fig. 2. whereon to secure the tube fig. 4. when applied to the nosle. The joints of the pipes, when put together for use, should be made air tight, by means of bees wax or some stronger cement, till they reach the bottom of the vessel, when there is no farther need of this precaution. The horizontal pipes should run by the side of the kelson the whole length of the hold. The tin plates of which K is made, should be punched in holes, like the rose of a watering pot, in two or three lines only at most, and then formed into a tube, with the rough side outwards L may have four or five lines of the like perforations. M, and the rest, should gradually increase in their number as they advance towards the middle of the hold, and continue fully perforated to the last pipe which should be closed at its end to prevent the ingress of the corn It is the centre of the cargo which most requires ventilating, yet air should pervade the whole. Like the trade-winds, it will direct its course to the part most heated, and, having effected its salutary purpose there, will disperse itself to refresh the mass.

Where the hatches are close-caulked, to prevent the influx of water, vent-holes may be bored in convenient parts of the deck, to be bunged up, and opened occasionally, from whence the state of the corn may be known by the effluvia which ascend when the ventilator is working.

The power of the ventilator is determined by the square of its diameter multiplied into the length of the stroke, and that again by the number of strokes in any given time.

The air-vessel or forcing pump, with the rest of the apparatus here described, is adapted to a vessel of 120 tons burden; but by lengthening the air vessel, extending its diameter to 14 inches, and adding 10 inches more to the length of the stroke, a power may be obtained of ventilating a cargo of 400 tons within the hour. If this machine be properly wrought for one hour every day, or even every two days, beginning the operations immediately when the corn is put on board, the cargo may be preserved from taint or injury of every kind during the longest voyage.

VERDEN, a duchy of Germany, in the circle of Lower Saxony. It is bounded on the east and south by that of Lunenburg; on the west, by the Weser and the duchy of Bremen; and on the north, by the duchies of Bremen and Lunenburg; extending both in length and breadth about 2[illegible] miles. It consists chiefly of heaths and high dry lands; but there are good marshes on the rivers Weser and Aller. In 1712, the Danes wrested this duchy from Sweden, and, in 1715, ceded it to the king of Great Britain, as elector of Hanover; which cession, in 1718, was confirmed by the Swedes. The inhabitants are Lutherans.

VERDIGRIS, or Acetite of Copper. See that article, *Encycl.* where an account is given of the process by which verdigris was long manufactured. A different, and more economical process, however, has for some years been practised in Montpellier, which is worthy of notice, because it may be adopted in this country by substituting the husks of gooseberries or currants for those of grapes.

In the manufacture of verdigris, the materials are copper and the husks of grapes after the last pressing. The copper is formed into round plates, half a line in thickness, and from twenty to twenty five inches in diameter. Each plate, at Montpellier, is divided into twenty-five laminæ, forming almost all oblong squares of from four to six inches in length, three in breadth, and weighing about four ounces. They are beat separately with the hammer on an anvil to smooth their surfaces, and to give the copper the necessary consistence. Without this precaution it would exfoliate, and it would be more difficult to scrape the surface in order to detach the oxydated crust. Besides this, scales of pure metal would be taken off, which would hasten the consumption of the copper.

The husks, which should not be too much pressed, are first made to ferment by being put into close vats, and the fermentation is generally completed in three or four days The time, however, must vary according to the temperature in which they are kept, and other circumstances. Whilst the husks are fermenting, a preliminary preparation is given to the copper plates. This consists in dissolving verdigris in water in an earthen vessel, and rubbing over each plate with a piece of coarse linen dipped in this solution. The plates are then immediately placed close to each other, and left in that manner to dry. Sometimes the plates are only laid on the top of the fermented husks, or placed under those which have been already used for causing the copper to oxydate It has been observed, that when this operation has not been employed, the plates grow black at the first operation, instead of becoming green. It is not, however, necessary to those which have been once used, and are to be used again.

When the plates are thus prepared, and the husks have been brought to ferment, the workmen try whether the latter are proper for the process, by placing under them a plate of copper, and leaving it buried there for twenty-four hours. If the plate, after this period, is found covered with a smooth green crust, in such a manner that none of the metal appears, they are then thought fit for being disposed in layers with the copper. On the other hand, if drops of water are observed on the surface of the plates, the plates are said to *sweat*, and it is concluded that the heat of the husks has not sufficiently subsided. They consequently defer making another trial till the next day. When they are assured that the husks are in a proper state, they form them into layers in the following manner:

The plates are all put into a box, which, instead of having a bottom, is divided in the middle by a wooden grate. The plates disposed on this grate are so strongly heated by a chaffing dish placed under them, that the woman employed in this labour is sometimes obliged to

Verdigris, Verdun

to take them up with a cloth, in order that she may not burn her hands. As soon as they have acquired that heat, they are put into jars in layers with the husks. Each jar is then closed with a covering of straw, and left to oxydate. Thirty or forty pounds of copper, more or less according to the thickness of the plates, are put into each jar. At the end of ten, twelve, fifteen, or twenty days, the jar is opened; and if the husks are white, it is time to take out the plates. The crystals are then seen detached, and of a silky appearance on their surface. The husks are thrown back, and the plates are put in what is called *relai*. For that purpose they are immediately deposited in a corner of the cellar on sticks ranged on the floor. They are placed in an upright position, one leaning against the other; and at the end of two or three days they are moistened, by taking them up in handfuls and immersing them in water in earthen pans. They are deposited quite wet in their former position, and left there for seven or eight days; after which they are once or twice immersed again. This immersion and drying are renewed six or eight times every seven or eight days. As the plates were formerly put into wine, these immersions were called *one wine*, *two wines*, *three wines*, according to the number of times. By this process the plates swell up, the green is nourished, and a coat of verdigris is formed on all their surfaces, which may be easily detached by scraping them with a knife.

This verdigris, which is called *fresh* verdigris, *moist* verdigris, is sold by the manufacturers to people who dry it for foreign exportation. In this first state it is only a paste, which is carefully pounded in large wooden troughs, and then put into bags of white leather, a foot in height and ten inches in diameter. These bags are exposed to the air or the sun, and are left in that state till the verdigris has acquired the proper degree of dryness. By this operation it decreases about 50 *per cent.* more or less according to its primitive state. It is said to stand proof by the knife, when the point of that instrument pushed against a cake of verdigris through the skin cannot penetrate it. White lead may be made by a similar process.

Crystallized VERDIGRIS is manufactured at Montpellier in the following manner: A vinegar, prepared by the distillation of sour wine, is put into a kettle, and boiled on the common verdigris. After saturation the solution is left to clarify, and then poured into another kettle of copper, where it is evaporated till a pellicle forms on the surface. Sticks are then immersed into it, and by means of some packthread are tied to some wooden bars that rest on the edge of the kettle. These sticks are about a foot long, and are split cross-wise nearly two inches at the end, so that they open into four branches, kept at about the distance of an inch from each other by small bags. The crystals adhere to these sticks and cover them entirely, forming themselves into groups or clusters, of a dark blue colour, and a rhomboidal shape. Each cluster weighs from five to six pounds. Three pounds of moist verdigris are required for one pound of the crystals; the undissolved residuum is thrown away.

VERDUN, an ancient, strong, and considerable town of France, in the department of Meuse, and late province of Lorrain, with a bishop's see, and a strong citadel. Its fortifications were constructed by the Chevalier de Ville and Marshal de Vauban. The latter was a native of this place. In 1755, great part of the cathedral was destroyed by lightning. Verdun was taken by the Prussians in 1792, but retaken by the French soon after. The inhabitants are noted for the fine sweetmeats they make. It is seated on the river Maese, which runs through the middle, 42 miles south-west of Luxemburg, and 150 east of Paris E. Lon. 5° 28' N. lat. 43° 9.

Vermifuge.

VERMIFUGE, a medicine which expels worms from the intestines. Of these medicines numbers are daily advertised in the newspapers as infallible, though the ingredients of which they are composed are carefully kept secret. We think it our duty therefore to assure our readers, that the medicines vended by quacks are generally the very same that would be prescribed by a regular physician for the disease in which they are pretended to be specifics, with this only difference, that the unseen and unprincipled quack generally prescribes them in more powerful doses than the regular physician deems safe for his patient. Thus Ching's famous worm medicine, which has been so strenuously recommended, is nothing more than mercury given in the very same form in which it is given by every physician; but Ching gives it in doses, which, though they have not injured the children of a bishop and a judge, we have *known* to *salivate* other children to the great hazard of their lives. It is indeed wonderful that parents should trust the health and the lives of their children to men whom they never saw, and whom they know to be not oppressed with an over delicate sense of honour, in preference to a man of science who has a character to support, and who is probably their friend, and almost always their acquaintance.

Of the different vermifuges, however, it must be confessed that the greater number are liable occasionally to fail. One of the most powerful which we have mentioned in the article MEDICINE, *Encycl.* is composed of the spiculæ of the *cowhage* or *cow-itch*; and since that article was published, it has come more into use, chiefly through the recommendation of Mr Chamberlaine surgeon. He says that a tea spoonful of the electuary (See MEDICINE, *Encycl.* p. 342.) may be safely given to a young child, and one or even two table spoonfuls to adults. The medicine is to be taken in the morning fasting; and the dose to be repeated for two or three mornings, after which a gentle purge completes the cure. This medicine, however, Mr Chamberlaine prohibits in every case where there is a tendency to inflammation in any part of the intestinal canal, or where the mucus has been carried off or greatly diminished by dysentery or any other cause.

Dr Haemmerlin of Ulm has lately recommended as a very powerful and safe vermifuge the coraline of Corsica, and says that it has been so used in that island with complete success from time immemorial. It is a fucus adhering to the rocks washed by the sea, and sometimes to the stones and shells thrown upon the shore. It is found in little tufts. It is generally of a yellow colour, with a reddish tincture. When dried, as it appears when offered for sale, it contains a strong smell of the sea. It consists of little cartilaginous stalks, with full threads, gradually cylindrical and tubulated. Its taste is salt and unpleasant. In the system of plants of Linnæus, it belongs to the class *cryptogamia*. Its most com-

mon

nish names are, sea rock moss; the Grecian herb; lemithochorton; and the coraline of Corsica. It is the *conferva helminthortos* of Schwendimann, and the *fucus helminthochorton* of Latourette. There is reason to think that all those species of fucus whose texture is soft and spungy, might be applied to the same medicinal uses. There is a sort of red coraline found in Sweden which, according to some writers, is a greater destroyer of worms than any other known substance; being not too strong for the stomach either of infants or of adults. Schwendimann asserts that the *conferva dichotoma* of Linnæus, which is found in the ditches in England, bears a strong analogy to the coraline of Corsica. Might not this conferva be tried as a vermifuge? The Corsican coraline is in great estimation in the pharmacopœias of the Continent, especially in that of Geneva, in which is given a recipe for preparing a syrup of it.

VERMONT, one of the United States of North America, bounded on the north by Canada; on the east, by the river Connecticut, which divides it from New Hampshire; on the south, by Massachussets; and on the west, by New York. It is about 155 miles long, and 60 broad, and is divided into 7 counties. A chain of high mountains, running north and south, divides this state nearly in the centre, between the river Connecticut and lake Champlain. The height of land is generally from 20 to 30 miles from the river, and about the same distance from the New York line. The natural growth upon this mountain is hemlock, pine, spruce, and other evergreens: hence it has always a green appearance, and, on this account, has obtained the descriptive name of Vermont, from the French *Verd Mont*, Green Mountain. On some high parts of this mountain, snow lies till May, and sometimes till July. The country is generally hilly, but not rocky. It is finely watered, the soil is very fertile, and there is not a better climate in the world. The inhabitants have very lately been estimated at 100,000. The bulk of them are emigrants from Connecticut and Massachusets. The principal town is Bennington, but the assembly generally hold their sessions at Windsor.

VESPA (See *Encycl.*). A new species of this genus of insects has been lately described by *Cuvier*, in a note read before the Philomathic Society of Paris. It has some resemblance to the *vespa nidulans* of Fabricius, which, as is generally known, is a native of certain parts of America. The nests of the vespa nidulans are constructed of a very fine web, of a very solid and pretty white paste. Their form is that of a bell closed upon all sides, excepting a narrow hole at the bottom; and they are suspended from the branches of trees.

The *vespa* described by Cuvier, which is a native of Cayenne in America, has in general more volume than the preceding species, and its paste is grey, coarser, less homogeneous, and less solid. The bottom of its nest also, in lieu of being shaped funnel like, is flat, and the orifice appears at one of the sides of the bottom part, and not in the middle. In the country where it is found, this species of wasp is called the *tatou fly* (*mouche tatou*). It differs greatly in form from that which Fabricius has described; it is all entirely of a shining black; the first articulation, or joint of its abdomen, is narrow, and in form of a pear; the second, larger than the others, is in form of a bell: the wings are brown. The following is the character assigned to it by Cuvier:

Vespatatua, Nigra, Nitida, Alis fuscis, abdomine pedicellato.

VESPERTILIO (see *Encyc.*) has been subjected to some cruel, but curious experiments, by the Abbé Spallanzani and M. de Jurine. The former of these philosophers having let loose several bats in a chamber perfectly dark, found that they flew about in it without any impediment, neither rushing against any thing in the apartment, nor touching the walls with their wings. This surprised him; but imagining that they were conducted by some glimpse of light which he did not perceive, he blindfolded them with a small and very close hood. They then ceased to fly; but he observed, at the same time, that this did not proceed from any deprivation of light, but rather from the constraint thence occasioned, especially when a hood of a very light texture was attended with the same effect.

He then conceived the idea of pasting up the eyes of the bats with a few drops of size or gum; but they still flew about in the same manner as if their eyes had been open. As this, however, was not sufficient, he pasted up the eyes of these animals with round bits of leather; and this even did not impede them in their flight.

That he might at length be certain of his object, he blinded them entirely, either by burning the cornea with a red hot wire, or by pulling out the pupil with a pair of small pincers, and scooping out the eye entirely. Not contented even with this precaution, he covered the wounds with pieces of leather, that the light might have no influence whatever on the remains of the organs which had been destroyed. The animals seemed to suffer very much by this cruel operation; but when they were compelled to use their wings, either by day or by night, and even in an apartment totally dark, they flew perfectly well, and with great caution, towards the walls, in order to suspend themselves when they wished to rest. They avoided every impediment, great or small, and flew from one apartment to another, backwards and forwards, through the door by which they were connected, without touching the frame with their wings. In a word, they shewed themselves as bold and lively in their flight as any other animals of the same species which enjoy the use of their eye-sight.

These experiments were repeated by M. Jurine, and with the same results. Spallanzani had supposed that the bat possessed some organ or sense which is wanting in the human species, and which supplies to these animals the place of vision; and Jurine determined to ascertain the truth or falsehood of this hypothesis by anatomical researches. During the course of these, he found the organ of hearing very great in proportion to that of other animals, and a considerable nervous apparatus assigned to that part. The upper jaw also is furnished with very large nerves, which are expanded in a tissue on the muzzle.

M Jurine then extended his experiments to the organ of hearing and that of smell. Having put a small hood on a long-eared bat, it immediately pulled it off, and flew. He stopped up its ears with cotton; but it freed itself in the like manner from that inconvenience. He then put into its ears a mastic of turpentine and wax. During the operation the animal shewed a great deal of impatience, and flew afterwards very imperfectly.

A long-eared bat, the ears of which had been bound up, flew very badly: but this did not arise from any pain

pain occasioned by the ligature; for when its ears were sewed up, it flew exceedingly well. In all probability the animal would have preferred having its ears bound up to having them sewed. Sometimes it flew towards the cieling, extending its muzzle before it settled.

M. Jurine poured liquid pomatum into the ears of a bat which enjoyed the use of its sight. It appeared to be much affected by this operation; but when the substance was removed it took flight. Its ears were again filled, and its eyes were taken out; but it flew then only in an irregular manner, without any certain or fixed direction.

The ears of a horse shoe bat, which had the use of its sight, were filled with tinder mixed with water. It was uneasy under the operation, and appeared afterwards restless and stunned; but it conducted itself tolerably well. On being blinded, it rushed with its head against the cieling, and made the air resound with strokes which it gave itself on the muzzle. This experiment was repeated on other bats with the like effects.

The tympanum of a large horse-shoe bat was pierced with a pin (*trois quart*). The animal appeared to suffer much from the operation, and fell down in a perpendicular direction when thrown into the air. It died next morning. The same effect was produced on piercing the tympanum of a long-eared bat with a needle.

The author then made very accurate researches on the difference between the organisation of the brain of these two kinds of bats; and, after a careful dissection, found that the eye of the long eared bat is much larger than that of the horse shoe bat, but that the optic nerve is proportioned to it. The outer part of the ear of the former is much larger than that of the latter, but the interior part is smaller.

The horse shoe bat is indemnified for this difference by a greater extension of the organ of smell, as evidently appears when the external elevations and irregularities of its muzzle are examined. When it is about to take flight, it agitates its nose much more than the long-eared bat.

From these experiments, the author concludes: *First*, That the eyes of the bat are not indispensably necessary to it for finding its way; *secondly*, That the organ of hearing appears to supply that of sight in the discovery of bodies, and to furnish these animals with different sensations to direct their flight, and enable them to avoid those obstacles which may present themselves.

VIBRATION FIGURES, are certain figures, formed by sand or very dry saw-dust, on a vibrating surface, which is connected with the sensation of sound in our organs of hearing. If the surface, on which the figures are to be formed, be strewed over with bodies easily put in motion, these, during the vibration, remain on the parts at rest, and are thrown from the parts in motion. The form of the parts at rest, which will be shewn by the sand that remains unmoved, and which, in general, is symmetric, is called a *vibration figure*. To produce such a figure, nothing is necessary but to know the method of bringing that part of the surface which you wish not to vibrate into a state of rest, and of putting in motion that which you wish to vibrate. On this depends the whole expertness of producing vibration figures.

Thus take a square piece of glass, pretty thin, and very smooth, such as that used for windows, about four or five inches over, or even more. Smooth it at the edges on a grinding-stone; strew a little saw-dust over its surface, and lay hold of it gently with the thumb and fore-finger of the left hand. Holding it thus by the middle, with the right hand rub a violin bow softly against one of its edges, drawing the bow either up or down in a direction almost perpendicular to the surface of the glass, and you will see a tremulous movement, and the whole dust leap about. If the bow be exactly in the middle of one of the sides, the dust will arrange itself almost in the direction of the two diagonals, dividing the square into four isosceles triangles. If the bow be applied at a quarter only of the distance of the one corner from the other, the dust will arrange itself in such a manner as to be found in the two diameters of the square, dividing it into four equal squares. At other times, when the bow deviates a little, the dust forms a figure like a double C, when the two letters are joined back to back. If the square be held by the two extremities of the diameter, opposite to that against which the bow is applied, the dust will form a kind of oval, one of the axes of which will be the [illegible] diameter. If the glass be of a circular figure, and be held by the middle, the dust will arrange itself in such a manner as to form the six radii of a regular hexagon. These discoveries were made by Dr Chladni, about the time that he invented the musical instrument, to which he gave the name of EUPHON (see that article, *Suppl.*); and as he found the vibration figures to vary in form with the various tones produced by the vibrating substances, a prosecution of his experiments may probably contribute to throw new light on the philosophy of musical sounds. We shall therefore give, from the 3d volume of *Neues Journal der Physik*, by Professor Gren, a few directions for making such experiments.

Vibration Figures, Vieta.

Any sort of glass may be employed, provided its surface be smooth; and when the plate has acquired the proper vibration, it should be kept in that state for some seconds, by continuing to rub it with the bow. The figures will thus be accurately formed.

Such plates should be procured as are pretty equal in thickness. It may be said, in general, that a plate the thinner it is will be so much the fitter for these experiments, though in this respect there is a certain minimum. In small plates, such as those that are circular, and not above six inches in diameter, the observation is general; but in larger plates too great thinness is prejudicial. Besides, it will be found that very thin glass is commonly very uneven, and must therefore be unfit for the experiments.

In practising the experiments, it will be proper to have plates of different sizes; and the sand employed should not be too fine. In other words, it must be of such a nature that when you incline the glass-plate it may readily roll off; because, in that case, it will be easily thrown from the vibrating parts. It will be of advantage that it be mixed with fine dust, which shews peculiar phenomena during the experiments, as it collects itself at one place of the vibrating part.

The plate must be equally bestrewed with sand, and not too thick, as the lines will then be exceedingly fine, and the figures will acquire a better defined appearance.

VIETA (Francis), a very celebrated French mathematician, was born in 1540 at Fontenai, or Fontenai-le-Comté, in Lower Poitou, a province of France. *Hutton's Mathematical Dictionary.*

He

Vieta. He was Master of requests at Paris, where he died in 1603, being the 63d year of his age. Among other branches of learning in which he excelled, he was one of the most respectable mathematicians of the 16th century, or indeed of any age. His writings abound with marks of great originality, and the finest genius, as well as intense application. His application was such, that he has sometimes remained in his study for three days together without eating or sleeping. His inventions and improvements in all parts of the mathematics were very considerable. He was in a manner the inventor and introducer of Specious Algebra, in which letters are used instead of numbers, as well as of many beautiful theorems in that science. He made also considerable improvements in geometry and trigonometry. His angular sections are a very ingenious and masterly performance: by these he was enabled to resolve the probem of Adrian Romanus, proposed to all mathematicians, amounting to an equation of the 45th degree. Romanus was so struck with his sagacity, that he immediately quitted his residence of Wirtzbourg in Franconia, and came to France to visit him, and solicit his friendship. His Apollonius Gallus, being a restoration of Apollonius's tract on Tangencies, and many other geometrical pieces to be found in his works, shew the finest taste and genius for true geometrical speculations.—He gave some masterly tracts on Trigonometry, both plane and spherical, which may be found in the collection of his works, published at Leyden in 1646, by Schooten, besides another large and separate volume in folio, published in the author's life-time, at Paris, in 1579, containing extensive trigonometrical tables, with the construction and use of the same, which are particularly described in the introduction to Dr Hutton's Logarithms, p. 4. &c. To this complete treatise on trigonometry, plane and spherical, are subjoined several miscellaneous problems and observations; such as, the quadrature of the circle, the duplication of the cube, &c. Computations are here given of the ratio of the diameter of a circle to the circumference, and of the length of the sine of 1 minute, both to a great many places of figures; by which he found that the sine of 1 minute is

between 2908881959
and 2908882056;

also the diameter of a circle being 1000, &c. that the perimeter of the inscribed and circumscribed polygon of 393216 sides will be as follows, viz. the

perim. of the inscribed polygon - 31415926535
perim. of the circumscribed polygon 31415926537

and that therefore the circumference of the circle lies between those two numbers.

Vieta having observed that there were many faults in the Gregorian Kalendar, as it then existed, composed a new form of it, to which he added perpetual canons, and an explication of it, with remarks and objections against Clavius, whom he accused of having deformed the true Lelian reformation, by not rightly understanding it.

Besides these, it seems a work, greatly esteemed, and the loss of which cannot be sufficiently deplored, was his *Harmonicon Cœleste*, which, being communicated to father Mersenne, was, by some perfidious acquaintance of that honest-minded person, surreptitiously taken from him and irrecoverably lost, or suppressed, to the great detriment of the learned world. There were also, it is said, other works of an astronomical kind, that have been buried in the ruins of time.

Vieta was also a profound decipherer, an accomplishment that proved very useful to his country. As the different parts of the Spanish monarchy lay very distant from one another, when they had occasion to communicate any secret designs, they wrote them in ciphers and unknown characters during the disorders of the league. The cipher was composed of more than 500 different characters, which yielded their hidden contents to the penetrating genius of Vieta alone. His skill so disconcerted the Spanish councils for two years, that they published it at Rome, and other parts of Europe, that the French king had only discovered their ciphers by means of magic.

VINTAIN, a town, situated about two miles up a creek on the southern side of the river Gambia. It is much resorted to by Europeans, on account of the great quantities of bees-wax which are brought hither for sale. The wax is collected in the woods by the Feloops, a wild and unsociable race of people. Their country, which is of considerable extent, abounds in rice; and the natives supply the traders, both on the Gambia and Cassamansa rivers, with that article, and also with goats and poultry, on very reasonable terms. The honey which they collect is chiefly used by themselves in making a strong intoxicating liquor, much the same as the mead which is produced from honey in Great Britain.

In their traffic with Europeans, the Feloops generally employ a factor, or agent, of the Mandingo nation, who speaks a little English, and is acquainted with the trade of the river. This broker makes the bargain; and, with the connivance of the European, receives a certain part only of the payment; which he gives to his employer as the whole; the remainder (which is very truly called the *cheating money*) he receives when the Feloop is gone and appropriates to himself as a reward for his trouble. Vintain, according to Mr Park, from whose valuable travels this account of the Feloops is taken, is situated in 13° 9′ North Lat. and 15° 56′ Long West from Greenwich.

VIRGINITY, the test or criterion of a virgin; or that which intitles her to the denomination. See Hymen, *Encycl.*

VISION. In the article Optics, n° 154. (*Encycl.*), it is said, that as we have a power of contracting or relaxing the *ligamenta ciliaria*, and thereby altering the form of the crystalline humour of the eye, we hence see objects distinctly at different distances. It appears, however, from some experiments made by Mr Everard Home and Mr Ramsden, in the year 1794, that this power of contracting and relaxing the ligamenta ciliaris is not alone sufficient to account for the phenomenon. Conversing with Mr Home on the different uses of the chrystalline humour, Mr Ramsden said, that as that humour "consists of a substance of different densities, the central parts being the most compact, and from thence diminishing in density gradually in every direction, approaching the vitreous humour on one side, and the aqueous humour on the other, its refractive power becomes nearly the same with that of the two contiguous substances. That some philosophers have stated the use of the crystalline humour to be, for accommodating

commodating the eye to see objects at different distances; but the firmness of the central part, and the very small difference between its refractive power near the circumference and that of the vitreous or the aqueous humour, seemed to render it unfit for that purpose; its principal use rather appearing to be for correcting the aberration arising from the spherical figure of the cornea, where the principal part of the refraction takes place, producing the same effect that, in an achromatic object-glass, we obtain in a less perfect manner by proportioning the radii of curvature of the different lenses. In the eye the correction seems perfect, which in the object-glass can only be an approximation; the contrary aberrations of the lenses not having the same ratio: so that, if this aberration be perfectly corrected, at any given distance from the centre, in every other it must be in some degree imperfect.

"Pursuing the same comparison: In the achromatic object-glass we may conceive how much an object must appear fainter from the great quantity of light lost by reflection at the surfaces of the different lenses, there being as many primary reflections as there are surfaces; and it would be fortunate if this reflected light was totally lost. Part of it is again reflected towards the eye by the interior surfaces of the lenses; which, by diluting the image formed in the focus of the object-glass, makes that image appear far less bright than it would otherwise have done, producing that milky appearance so often complained of in viewing lucid objects through this sort of telescope.

"In the eye, the same properties that obviate this defect, serve also to correct the errors from the spherical figure, by a regular diminution of density, from the centre of the crystalline outward. Every appearance shews the crystalline to consist of laminæ of different densities; and if we examine the junction of different media, having a very small difference of refraction, we shall find that we may have a sensible refraction without reflection. Now, if the difference between the contiguous media in the eye, or the laminæ in the crystalline, be very small, we shall have refraction without having reflection; and this appears to be the state of the eye; for although we have two surfaces of the aqueous, two of the crystalline, and two of the vitreous humour, yet we have only one reflected image; and that being from the anterior surface of the cornea, there can be no surface to reflect it back, and dilute an image on the retina.

"This hypothesis may be put to the test whenever accident shall furnish us with a subject having the crystalline extracted from one eye, the other remaining perfect in its natural state; at the same time we may ascertain whether or no the crystalline is that part of the organ which serves for viewing objects at different distances distinctly. Seeing no reflection at the surface of the crystalline, might lead some persons to infer that its refractive power is very inconsiderable; but many circumstances shew the contrary: yet what it really is may be readily ascertained by having the focal length and distance of a lens from the operated eye, that enables it to see objects the most distinctly; also the focal length of a lens, and its distance from the perfect eye, that enables it to see objects at the same distance as the perfect eye: these data will be sufficient whereby to calculate the refractive power of the crystalline with considerable precision.

"Again, having the spherical aberration of the different humours of the eye, and having ascertained the refractive power of the crystalline, we have data from whence to determine the proportional increase of its density as it approaches the central part, on a supposition that this property corrects the aberration.

"An opportunity presented itself for bringing the observations of Mr Ramsden, respecting the use of the crystalline lens, to the proof. A young man came into St George's Hospital with a cataract in the right eye. The crystalline lens was readily extracted, and the union of the wound in the cornea took place unattended by inflammation; so that the eye suffered the smallest degree of injury that can attend so severe an operation. The man himself was in health, 21 years had been intelligent, and his left eye perfect: the other and 27 days after commonly short time in a diseased state, from every other defect but operation appeared to be free lens. ...ss of the crystalline

"A number of experiments were made ... perfect eye, assisted by a lens, and compared with imperfect eye. The aim of these trials, which were judiciously varied, was to ascertain whether the eye which had been deprived of the crystalline lens was capable of adjusting itself to distinct vision at different distances. Among other results, the perfect eye, with a glass of $6\frac{1}{8}$ inches focus, had distinct vision at 3 inches; the near limit was $1\frac{7}{8}$ inch, the distant limit less than 7 inches. The imperfect eye, with a glass $2\frac{2}{10}$ inches focus, with an aperture $\frac{1}{10}$ths of an inch, had distinct vision at $2\frac{7}{8}$ inches, the near limit $1\frac{7}{8}$ inch, and the distant limit 7 inches. The accuracy with which the eye was brought to the same point, on repeating the experiment, proved it to be uncommonly correct; and as he did not himself see the scale used for admeasurement, there could be no source of fallacy. From the result of this experiment, it appears that the range of adjustment of the imperfect eye, when the two eyes were made to see at nearly the same focal distance, exceeded that of the perfect eye. Mr Ramsden suggested a reason why the point of distinct vision of the imperfect eye might appear to the man himself nearer than it was in reality; namely, that from the imperfection of this organ he might find it easier to read the letters when they subtended a greater angle than at his real point of distinct vision. The experiments, however, appear to shew that the internal power of the eye, by which it is adjusted to see at different distances, does not reside in the crystalline lens, at least not altogether; and that if any agency in this respect can be proved to reside in the crystalline, the other powers, whatever they may be, are capable of exertion beyond their usual limits, so as to perform its office in this respect.

"From these considerations, and in consequence of other reflections tending to shew that an elongation of the optical axis is not probably the means of adjustment, these philosophers directed their enquiries to ascertain how far the curvature of the cornea might be subject to change. They found by trial that this part of the organ possesses a degree of elasticity which is very considerable, both for its perfection and its range; and by anatomical

Viſion. anatomical diſſection it was found that the four ſtraight muſcles of the eye do in effect terminate in the cornea at their tendinous extremities; that the whole external lamina of the cornea could by gentle force be ſeparated, by means of theſe muſcles, from the eye; ſo that the tendons ſeem loſt in the cornea, and this laſt has the appearance of a central tendon. It was alſo ſeen that the central part of the cornea is the thickeſt and the moſt elaſtic.

"Theſe were conſiderable advances towards eſtabliſhing the hypotheſis of adjuſtment by the external curve of the eye. It remained to be ſhewn, by experiments on the living ſubject, that this curve does really vary in the due direction, when the mind perceives the diſtinct viſible ſenſation of objects at different diſtances. For this purpoſe Mr Ramſden provided an apparatus, conſiſting of a thick board ſteadily fixed, in which was ... ; the ſquare hole large enough to admit a perſon's upper and lower forehead and chin reſting against either of the ſides; ſo that bars, and the cheek protruded, the head was ſteadily when the ...ng on three ſides; and in this poſition the fixed eye projected beyond the outer ſurface of the board. A microſcope, properly mounted, ſo as with eaſe to be ſet in every requiſite poſition, was applied to view the cornea with a magnifying power of thirty times. In this ſituation, the perſon whoſe eye was the object of experiment was deſired to look at the corner of a chimney, at the diſtance of 235 yards, through a ſmall hole in a braſs plate, fixed for that purpoſe, and afterwards to look at the edge of the hole itſelf, which was only ſix inches diſtant. After ſome management and caution, which the delicate nature of theſe experiments requires, the motion of the cornea, which was immediately perceptible, became very diſtinct and certain. The circular ſection of its ſurface remained in a line with the wire in the field of the microſcope, when the eye was adjuſted to the diſtant object, but projected conſiderably beyond it when adapted to the near one. When the diſtant object was only 90 feet from the obſerver, and the near object ſix inches, the difference in the prominence of the cornea was eſtimated at 1-800th of an inch. Theſe experiments were repeated and varied at different times and on different ſubjects. The obſerver at the microſcope found no difficulty in determining, from the appearance of the cornea, whether the eye was fixed on the remote or the near object.

"From theſe different experiments Mr Home conſiders the following facts to have been aſcertained:

"1 That the eye has a power of adjuſting itſelf to different diſtances when deprived of the cryſtalline lens; and therefore the fibrous and laminated ſtructure of that lens is not intended to alter its form, but to prevent reflections in the paſſage of the rays through the ſurfaces of media of different denſities, and to correct ſpherical aberration.

"2 That the cornea is made up of laminæ; that it is elaſtic, and when ſtretched is capable of being elongated 1 11th part of its diameter, contracting to its former length immediately upon being left to itſelf.

"3. That the tendons of the four ſtraight muſcles of the eye are continued on to the edge of the cornea, and terminate, or are inſerted, in its external laminæ: their action will therefore extend to the edge of the cornea.

"4. That in changing the focus of the eye from ſeeing with parallel rays to a near diſtance, there is a viſible alteration produced in the figure of the cornea, rendering it more convex; and when the eye is again adapted to parallel rays, the alteration by which the cornea is brought back to its former ſtate is equally viſible."

Mr Home made many other experiments with a view to throw light upon this curious ſubject; and the reſult of the whole appears to be, that the adjuſtment of the eye is produced by three different changes in that organ; an increaſe of curvature in the cornea, an elongation of the axis of viſion, and a motion of the cryſtalline lens. Theſe changes, in a great meaſure, depend upon the contraction of the four ſtraight muſcles of the eye. Mr Ramſden, from computations grounded on the principles of optics and general ſtate of the facts, calculates that the increaſe of curvature of the cornea may be capable of producing one-third of the effect, and that the change of place of the lens, and elongation of the axis of viſion, ſufficiently account for the other two thirds of the quantity of adjuſtment neceſſary to make up the whole.

VITALITY, the power of ſubſiſting in life, which the faſhionable philoſophers of the French and German ſchools attribute to *chemiſtry*. For a confutation of their abſurd and impious jargon on this ſubject, we refer our readers, with ſome degree of confidence, to the articles PHYSIOLOGY (*Encycl.*), and *Animal* SUBSTANCES (*Suppl.*)

VIVERRA (ſee *Encycl.*) A new ſpecies of this genus of animals was diſcovered by Vaillant during his laſt travels in Africa; at leaſt he ranks under the generic name *Viverra*, the animal of which he gives the following deſcription. Its body was of the ſize of that of a kitten ſix months old: it had a very large noſe, the upper jaw exceeding the lower near two-thirds of an inch in length, and forming a ſort of moveable ſnout reſembling that of the *conti* of Guiana. The fore feet were armed with four large claws, very ſharp and curved; the hind ones have each five, but they are ſhort and blunt. All the fur on the upper part of the body is marked with croſs bands of a deep brown colour, on a ground of light brown with which many white hairs are intermixed. The lower part of the body and inſides of the legs are of a reddiſh white. The tail, which is very fleſhy, and more than two thirds longer than the body, is black at the tip, and the reſt brown, intermixed with white hairs.

This animal employs its fore paws to dig very deep holes in the earth, in which it remains concealed during the day, not going out till ſun-ſet in queſt of food.

The Hottentots who accompanied our traveller called it *muys-hond* (a mouſe dog); a general name among the inhabitants of the Cape for all the ſmaller carnivorous quadrupeds.

VIVES (Ludovicus), the contemporary and friend of Eraſmus, was a native of Valentia in Spain. Though well trained in all the ſubtleties of the ſcholaſtic philoſophy at Paris, he had the good ſenſe to diſcover its futility, and diligently applied himſelf to more uſeful ſtudies. At Louvain he undertook the office of a preceptor, and exerted himſelf with great ability and ſucceſs in correcting barbariſm, chaſtiſing the corrupters of learning, and reviving a taſte for true ſcience and elegant letters. Eraſmus, with whom he lived upon the footing

Vives, Ultramarine.

footing of intimate friendſhip, ſpeaking of Vives when he was only 26 years of age, ſays, that there was no part of philoſophy in which he did not excel; and that he had made ſuch proficiency in learning, and in the arts of ſpeaking and writing, that he ſcarcely knew his equal. He wrote a commentary upon Auguſtine's treatiſe *De Civitate Dei*, which diſcovers an extenſive acquaintance with ancient philoſophy. Henry VIII. of England, to whom he dedicated this work, was ſo pleaſed with it, that he invited the author to his court, and made him preceptor to his daughter Mary. Though he diſcharged his office with great fidelity, yet in conſequence of his oppoſition to the king's divorce, he fell under his diſpleaſure; and it was not without difficulty that he eſcaped to Bruges, where he devoted the remainder of his days to ſtudy. He died in the year 1537, or, according to Thuanus, in 1541. With Eraſmus and Buddæus he formed a triumvirate of literature which did honour to the age. He wrote *De Prima Philoſophia*, "On the Firſt Philoſophy;" *De Explanatione Eſſentiarum*, "On the Explanation of Eſſences;" *De Cenſura Veri*, "On the Teſt of Truth;" *De Initiis, Sectis, et Laudibus Philoſophiæ*, "On the Origin, Sects, and Praiſes of Philoſophy;" and *De Corruptis Artibus et Tradendis Diſciplinis*, "On the Corruption of Science, and on Education." Theſe writings, of which the two laſt are the moſt valuable, diſcover great ſtrength of judgment, an extenſive knowledge of philoſophy, much enlargement of conception, uncommon ſagacity in detecting the errors of ancient and modern philoſophers, particularly of Ariſtotle and his followers, and, in fine, a mind capable of attempting things beyond the ſtandard of the age in which he lived. To all this he added great perſpicuity and elegance of ſtyle, not unworthy of the friend of Eraſmus.

ULTRAMARINE is a very fine blue powder, almoſt of the colour of the corn flower or blue bottle, which has this uncommon property, that, when expoſed to the air or a moderate heat, it neither fades nor becomes tarniſhed. On this account it is uſed in painting; but it was employed formerly for that purpoſe much more than at preſent, as ſmalt, a far cheaper article, was not then known. (See COBALT, in this *Suppl.*) Ultramarine is made of the blue parts of the lapis lazuli, by ſeparating them as much as poſſible from the other coloured particles with which they are mixed, and reducing them to a fine powder. The real lapis lazuli is found in the mountains of that part of Tartary called Bucharia, which extends eaſtwards from the Caſpian ſea, and particularly at Kalab and Budukſchu. It is ſent thence to the Eaſt Indies, and from the Eaſt Indies to Europe. Good ultramarine muſt be of a beautiful dark colour, and free from ſand as well as every other mixture. It muſt unite readily with oil; it muſt not become tarniſhed on a red-hot tile or plate of iron, and it ought to diſſolve in ſtrong acids, almoſt like the zeolite, without cauſing an efferveſcence. In the year 1763, an ounce of it at Paris coſt four pounds ſterling, and an ounce of *cendre d'outremer*, which is the refuſe, two pounds. The baſis of this colour was long ſuſpected to be copper. but the experiments of Margraff ſhewed that it was iron, in ſome unknown ſtate of combination. New light has been thrown on this ſubject by Morveau, who has diſcovered that ſelenite mixed with iron, when decompoſed by carbonaceous matter, yields a blue ſulphuret of iron of equal permanency with the true ultramarine.

At preſent, ſmalt of a good colour is often purchaſed at a dear rate and ſubſtituted for ultramarine: and it is found that the colour of this preparation of cobalt is more durable in the fire than even that of the lapis lazuli For the analyſis of lapis lazuli, ſee MINERALOGY, n° 69. *Suppl.*

Vortices.

VORTICES of Des Cartes are now juſtly exploded; but being the fiction of a very ſuperior mind, they are ſtill an object of curioſity as being the foundation of a great philoſophical romance. According to the author of that romance, the whole of infinite ſpace was full of matter; for with him matter and extenſion were the ſame, and conſequently there could be no void. This immenſity of matter he ſuppoſed to be divided into an infinite number of very ſmall cubes; all of which, being whirled about upon their own centres, neceſſarily gave occaſion to the production of two different elements. The firſt conſiſted of the angular parts which, having been neceſſarily rubbed off, by their mutual friction, conſtituted a yet ſmaller and moveable part of matter. The ſecond conſiſted of thoſe little globules that were formed by the rubbing off of the firſt. The interſtices betwixt theſe globules of the ſecond element were filled up by the particles of the firſt. But in the infinite colliſions, which muſt occur in an infinite ſpace filled with matter, and all in motion, it muſt neceſſarily happen that many of the globules of the ſecond element ſhould be broken and grinded down into the firſt. The quantity of the firſt element having thus been increaſed beyond what was ſufficient to fill up the interſtices of the ſecond, it muſt, in many places, have been heaped up together, without any mixture of the ſecond along with it. Such, according to Des Cartes, was the original diviſion of matter. Upon this infinitude of matter thus divided, a certain quantity of motion was originally impreſſed by the Creator of all things, and the laws of motion were ſo adjuſted as always to preſerve the ſame quantity in it, without increaſe, and without diminution. Whatever motion was loſt by one part of matter, was communicated to ſome other; and whatever was acquired by one part of matter, was derived from ſome other: and thus, through an eternal revolution from reſt to motion, and from motion to reſt, in every part of the univerſe, the quantity of motion in the whole was always the ſame.

But as there was no void, no one part of matter could be moved without thruſting ſome other out of its place, nor that without thruſting ſome other, and ſo on. To avoid, therefore, an infinite progreſs, he ſuppoſed that the matter which any body puſhed before it rolled immediately backwards to ſupply the place of that matter which flowed in behind it; as we may obſerve in the ſwimming of a fiſh, that the water which it puſhes before it immediately rolls backwards to ſupply the place of what flows in behind it, and thus forms a ſmall circle or vortex round the body of the fiſh. It was in the ſame manner that the motion originally impreſſed by the Creator upon the infinitude of matter neceſſarily produced in it an infinity of greater and ſmaller vortices, or circular ſtreams: and the law of motion being ſo adjuſted as always to preſerve the ſame quantity of motion in the univerſe, thoſe vortices either continued

for ever, or by their dissolution gave birth to others of the same kind. There was thus at all times an infinite number of greater and smaller vortices, or circular streams, revolving in the universe.

But whatever moves in a circle is constantly endeavouring to fly off from the centre of its revolution. For the natural motion of all bodies is in a straight line. All the particles of matter therefore, in each of those greater vortices, were continually pressing from the centre to the circumference, with more or less force, according to the different degrees of their bulk and solidity. The larger and more solid globules of the second element forced themselves upwards to the circumference, while the smaller, more yielding, and more active particles of the first, which could flow even through the interstices of the second, were forced downwards to the centre. They were forced downwards to the centre notwithstanding [illegible] their natural tendency was upwards to the [illegible] wood, when ference; for the same reason [illegible] upwards to the surface, notplunged in water, [illegible] natural tendency is downwards to the withstanding [illegible] because its tendency downwards is less strong than that of the particles of water, which, therefore, if one may say so, press in before it, and thus force it upwards. But there being a greater quantity of the first element than what was necessary to fill up the interstices of the second, it was necessarily accumulated in the centre of each of these great circular streams, and formed there the fiery and active substance of the sun. For, according to that philosopher, the solar systems were infinite in number, each fixed star being the centre of one; and he is among the first of the moderns who thus took away the boundaries of the universe: even Copernicus and Kepler, themselves, have confined it within what they supposed the vault of the firmament.

The centre of each vortex being thus occupied by the most active and moveable parts of matter, there was necessarily among them a more violent agitation than in any other part of the vortex, and this violent agitation of the centre cherished and supported the movement of the whole. But among the particles of the first element, which fill up the interstices of the second, there are many, which, from the pressure of the globules on all sides of them, necessarily receive an angular form, and thus constitute a third element of particles less fit for motion than those of the other two. As the particles, however, of this third element were formed in the interstices of the second, they are necessarily smaller than those of the second, and are therefore, along with those of the first, urged down towards the centre, where, when a number of them happen to take hold of one another, they form such spots upon the surface of the accumulated particles of the first element, as are often discovered by telescopes upon the face of that sun which enlightens and animates our particular system. Those spots are often broken and dispelled by the violent agitation of the particles of the first element, as has hitherto happily been the case with those which have successively been formed upon the face of our sun. Sometimes, however, they encrust the whole surface of that fire which is accumulated in the centre; and the communication betwixt the most active and the most inert parts of the vortex being thus interrupted, the rapidity of its motion immediately begins to languish, and can no longer defend it from being swallowed up and carried away by the superior violence of some other like circular stream; and, in this manner, what was once a sun becomes a planet. Thus the time was, according to the system, when the Moon was a body of the same kind with the sun, the fiery centre of a circular stream of ether, which flowed continually round her; but her face having been crusted over by a congeries of angular particles, the motion of this circular stream began to languish, and could no longer defend itself from being absorbed by the more violent vortex of the earth, which was then, too, a sun, and which chanced to be placed in its neighbourhood. The moon therefore became a planet, and revolved round the earth. In process of time, the same fortune, which had thus befallen the moon, befel also the earth [illegible] face was encrusted by a gross and ina[illegible] substance; the motion of its vortex [illegible] to languish, and it was absorbed by the greater vortex of the sun: but though the vortex of the earth had thus become languid, it still had force enough to occasion both the diurnal revolution of the earth, and the monthly motion of the moon. For a small circular stream may easily be conceived as flowing round the body of the earth, at the same time that it is carried along by that great ocean of ether which is continually revolving round the sun; in the same manner, as in a great whirlpool of water, one may often see several small whirlpools, which revolve round centres of their own, and at the same time are carried round the centre of the great one. Such was the cause of the original formation and consequent motions of the planetary system. When a solid body is turned round its centre, those parts of it which are nearest, and those which are remotest from the centre, complete their revolutions in one and the same time. But it is otherwise with the revolutions of a fluid: the parts of it which are nearest the centre complete their revolutions in a shorter time than those which are remoter. The planets, therefore, all floating in that immense tide of æther which is continually setting in from west to east round the body of the sun, complete their revolutions in a longer or a shorter time, according to their nearness or distance from him.

This bold system was eminently fitted to captivate the imagination; and though fraught with contradictions and impossibilities, attempts have been made to revive it, even in this country, under different names. All those systems which represent the motions of the heavenly bodies as being the effect of the physical agency of æthers, of air, of fire, and of light, of which the universe is conceived to be full, labour under the same difficulties with the Cartesian hypothesis; and very few of them, if any, are so neatly put together. It is surely sufficient, however, to demolish this goodly fabric, barely to ask how an absolute infinity of matter can be divided into cubes, or any thing else? how there can possibly be interstices in a perfect plenum? or how in such a plenum any portion of matter can be thrust from its place?

URALIAN Cossacs, a people that inhabit the Russian province of Orenburg in Asia, on the south side of the river Ural. These Cossacs are descended from those of the Don: they are a very valiant race. They profess the Greek religion; but there is a kind of dissenters from the established religion, whom the Russians called *Roskolniki*, or Separatists, and who style themselves *Staroverski*, or Old Believers. They consider

der the service of the established church as profane and sacrilegious, and have their own priests and ceremonies. The Uralian Cossacs are all enthusiasts for the ancient ritual, and prize their beards almost equal to their lives. A Russian officer having ordered a number of Cossac recruits to be publicly shaved in the town of Yaisk, in 1771, this wanton insult excited an insurrection, which was suppressed for a time; but, in 1773, that daring impostor, Pugatchef, having assumed the name and person of Peter III. appeared among them, and taking advantage of this circumstance, and of their religious prejudices, roused them once more into open rebellion. This being at last effectually suppressed by the defeat and execution of the impostor (See SUWOROW, *Suppl.*), in order to extinguish all remembrance of this rebellion, the river Yaik was called *Ural*; the Yaik Cossacs were denominated *Uralian Cossacs*; and the town of Yaitsk, *Uralsk*. The Uralian Cossacs enjoy the right of fishing on the coast of the Caspian Sea, for 47 miles on each side of the river Ural. Their principal fishery is for sturgeons and beluga, whose roe supplies large quantities of caviare; and the fish, which are chiefly salted and dried, afford a considerable article of consumption in the Russian empire. In consequence of these fisheries, these Cossacs are very rich.

URBINO, a town of Italy, in the territory of the Pope, and capital of the duchy of Urbino, with an old citadel, an archbishop's see, and a handsome palace, where the dukes formerly resided. The houses are well built, and great quantities of fine earthen ware are made here. It is seated on a mountain, between the rivers Metro and Foglia, 18 miles south of Rimini, 58 east of Florence, and 120 north-east of Rome. E. Lon. 12. 40. N. lat. 43. 46.

URBINO, a duchy of Italy, in the territory of the church, bounded on the north by the gulph of Venice; on the south, by Perugino and Umbria; on the east, by the marquisate of Ancona; and on the west, by Tuscany and Romagna. It is about 55 miles in length, and 45 in breadth. Here is great plenty of game and fish; but the air is not very wholesome, nor is the soil fertile. Urbino is the capital.

URCEOLA, a lately discovered genus of the *pentandria* class, and *monogynia* order of plants, ranking immediately after TABERNÆ MONTANA (see *Encycl.*), and consequently belonging to the 30th natural order or class called *Contortæ* by Linnæus in his natural method of arrangement. One of the qualities of the plants of this order is their yielding, on being cut, a juice which is generally milky, and for the most part deemed of a poisonous nature. The genus is thus characterised by Dr Roxburgh: *Calyx* beneath five-toothed; corol one petaled, pitcher shaped, with its contracted mouth five toothed: nectary entire, surrounding the germs; follicles two, round, drupacious; seeds numerous, immersed in pulp. There is but one known species, which is thus described by the same eminent botanist;

URCEOLA ELASTICA: Shrubby, twining, leaves opposite, oblong, panicles terminal, is a native of Sumatra, Prince of Wales's Island, &c. Malay countries. *Stem* woody, climbing over trees, &c. to a very great extent, young shoots twining, and a little hairy, bark of the old woody parts thick, dark coloured, considerably uneven, a little scabrous, on which are found several species of moss, particularly large patches of lichen; the wood is white, light, and porous. *Leaves* opposite, short-petioled, horizontal, ovate, oblong, pointed, entire, a little scabrous, with a few scattered white hairs on the under side. *Stipules* none. *Panicle* terminal, brachiate, very ramous. *Flowers* numerous, minute, of a dull greenish colour, and hairy on the outside. *Bracts* lanceolate, one at each division and subdivision of the panicle. *Calyx* perianth, one-leaved, five toothed, permanent. *Corol* one petaled, pitcher shaped, hairy, mouth much contracted, five toothed, divisions erect, acute, nectary entire, cylindric, embracing the lower two-thirds of the germs. *Stamens*, filaments five, very short from the base of the corol. Anthers arrow shaped, converging, bearing their pollen in two grooves on the inside, near the apex; between these grooves and the insertions of the filaments they are covered with white soft ... *Pistil*, germs two; above the nectary they are very hairy ... tops. Style single, short; the margins of their truncated ... ovate, with a circular band, dividing it into ... Stigma ... portions of different colours. *Per.* Follicles two, ... laterally compressed into the shape of a kidney, wrinkled, leathery, about three inches in their greatest diameters—one celled, two valved. *Seeds* very numerous, reniform, immersed in firm fleshy pulp.

See Plate XLVII. where fig. 1. is a branchlet in flower of the natural size. 2. A flower magnified. 3. The same laid open, which exposes to view the situation of the stamens inserted into the bottom of the corol, the nectarium surrounding the lower half of the two germs, their upper half with hairy margins, the style and ovate party coloured; stigma appearing above the nectary. 4. Outside of one of the stamens; and, 5. Inside of the same, both much magnified. 6. The nectarium laid open, exposing to view the whole of the pistil. 7. The two seed vessels (called by Linnæus *folliclus*), natural size; half of one of them is removed, to shew the seed immersed in pulp. A portion thereof is also cut away, which more clearly shews the ... and shape of the seed.

From wounds made in the bark of this plant there oozes a milky fluid, which on exposure to the open air separates into an elastic coagulum, and watery liquid, apparently of no use, after the separation takes place. This coagulum is not only like the American caoutchouc or Indian rubber, but possesses the same properties; for which, see CAOUTCHOUC, both in the *Encycl.* and *Suppl.*

The chemical properties of this vegetable milk, while fresh, were found by Mr Howison, late surgeon on Prince of Wales's Island, surprisingly to resemble those of animal milk. From its decomposition, in consequence of spontaneous fermentation, or by the addition of acids, a separation takes place between its caseous and serous parts, both of which are very similar to those produced by the same processes from animal milk. An oily or butyrous matter is also one of its component parts, which appears upon the surface of the gum so soon as the latter has attained its solid form. He endeavoured to form an extract of this milk so as to approach to the consistence of new butter, by which he hoped to retard its fermentative stage, without depriving it of its useful qualities; but as he had no apparatus for distilling, the surface of the milk, that was exposed to the air, instantly formed into a solid coat, by which

Urinary, Urtica.

which the evaporation was in a great degree prevented. He, however, learned, by collecting the thickened milk from the inſide of the coats, and depoſiting it in a jelly pot, that, if excluded from the air, it might be preſerved in this ſtate for a conſiderable length of time; and even without any preparation he kept it in bottles, tolerably good, upwards of twelve months.

URINARY concretions. See *Animal Substances*, Suppl.

URTICA. See *Encycl.* where it is obſerved that the common nettle, though it has a place in the *materia medica*, is now very little uſed. It has lately been recommended, however, by *Zannetini*, a phyſician who attended the French army in Italy, as a good ſubſtitute in fevers for cinchona. The ſucceſs of ſome experiments, which he made with it in tertian and quartan ... ſanguine malignant fevers, ſurpaſſed, he ſays, his expectation. The nettle ... duces a ſpeedier effect than bark for it heats in a great degree, and when the doſe is pretty ſtrong, occaſions a lethargic ſleep. The doſe muſt never exceed a dram, and is given in wine two or three times in the courſe of 24 hours. Zannetini found this medicine of great ſervice to guard againſt that total exhauſtion which forms the principal character of malignant fevers; and he recommends a ſlight infuſion of it in wine as an excellent preſervative for thoſe who reſide in marſhy and inſalubrious diſtricts. In employing the nettle in fever, Zannetini gives the ſame caution as ought to be obſerved in regard to cinchona, that is, that it muſt not be employed where there is an inclination to inflammation, or where a continued fever, ariſing from obſtructions, exiſts. This diſcovery is not unworthy the attention of phyſicians, and de... leaſt to be farther inveſtigated, as a great deal would be ſaved if cinchona could be entirely diſpenſed with.

W.

Wales.

WALES, New South, is a country which muſt be intereſting on account of the ſingular colony which was ſettled there in the year 1788. Under the title *New Holland* (*Encycl.*) ſome account has been given of that ſettlement, as well as of the climate and the ſoil about Port Jackſon; but it will probably gratify the curioſity of our readers, if we give a ſhort hiſtory of thoſe European ſettlers, of whom it is to be hoped that they carried not with them, to that diſtant ſhore,

"Minds not to be changed by time or place."

This hiſtory we ſhall take from the accurate *Account of the Engliſh Colony in New South Wales*, by David Collins, Eſq; who went out with Governor Phillip, and continued to execute the offices of Judge-advocate and Secretary till the cloſe of the year 1796; and we ſhall begin our narrative from the diſembarkation of the firſt coloniſts, when his Majeſty's commiſſion to the governor, and the letters patent eſtabliſhing courts of criminal and civil judicature in the territory were read.

The criminal court was conſtituted a court of record, and was to conſiſt of the judge-advocate and ſuch ſix officers of the ſea and land ſervice as the governor ſhall, by precept iſſued under his hand and ſeal, require to aſſemble for that purpoſe This court has power to inquire of, hear, determine, and puniſh all treaſons, miſpriſions of treaſons, murders, felonies, forgeries, perjuries, treſpaſſes, and other crimes whatſoever that may be committed in the colony; the puniſhment for ſuch offences to be inflicted according to the laws of England as nearly as may be, conſidering and allowing for the circumſtances and ſituation of the ſettlement and its inhabitants. The charge againſt any offender is to be reduced into writing, and exhibited by the judge-advocate: witneſſes are to be examined upon oath, as well for as againſt the priſoner; and the court is to adjudge whether he is guilty or not guilty by the opinion of the major part of the court. If guilty, and the offence is capital, they are to pronounce judgment of death, in like manner as if the priſoner had been convicted by the verdict of a jury in England, or of ſuch corporal puniſhment as the court, or the major part of it, ſhall deem meet. And in caſes not capital, they are to adjudge ſuch corporal puniſhment as the majority of the court ſhall determine. But no offender is to ſuffer death unleſs five members of the court ſhall concur in adjudging him to be guilty, until the proceedings ſhall have been tranſmitted to England, and the king's pleaſure ſignified thereupon. The provoſt-marſhall is to cauſe the judgement of the court to be executed according to the governor's warrant under his hand and ſeal.

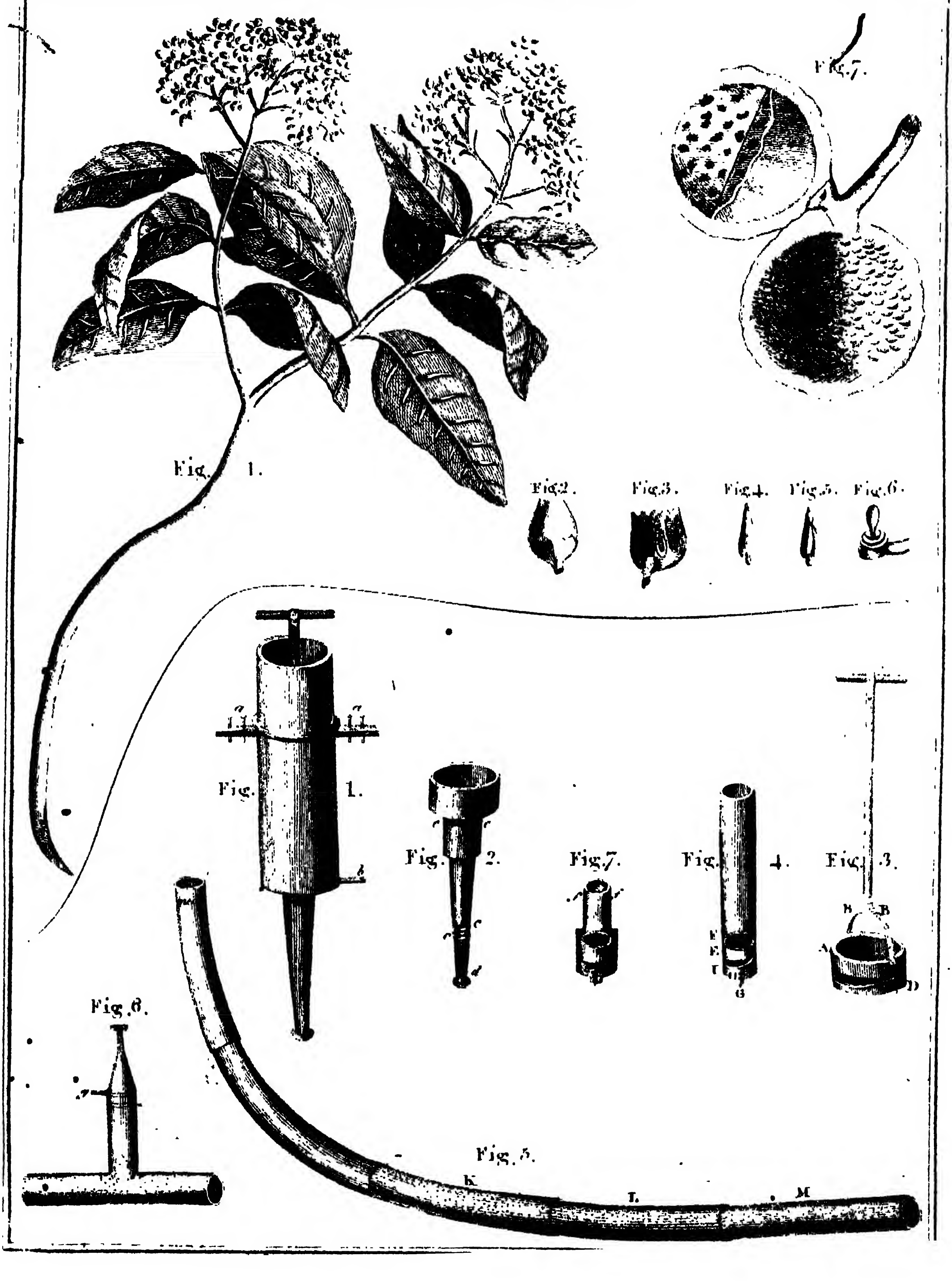
Beſide this court for the trial of criminal offenders, there is a civil court, conſiſting of the judge-advocate and two inhabitants of the ſettlement, who are to be appointed by the governor; which court has full power to hear and determine in a ſummary way all pleas of lands, houſes, debts, contracts, and all perſonal pleas whatſoever.

From this court, on either party, plaintiff or defendant, finding himſelf or themſelves aggrieved by the judgment or decree, an appeal lies to the governor, and from him, where the debt or thing in demand ſhall exceed the value of L. 300, to the king in council.

A vice-admiralty court was alſo appointed, for the trial of offences on the high ſeas; and the governor, lieutenant-governor, and judge-advocate, were by patent made juſtices of the peace, with a power in the governor to appoint other juſtices.

The ſituation which Governor Phillip had ſelected for his reſidence, and for the principal ſettlement, was the eaſt ſide of a cove in Port Jackſon, which he called *Sydney Cove*. Its latitude was found to be 33° 52′ 30″ ſouth, and its longitude 152° 19′ 30″ eaſt. This ſituation was choſen without due examination; for it ſoon appeared that the head or upper part of the cove wore a much more favourable appearance than the ground immediately about the ſettlement. From the natives, the new ſettlers met no oppoſition: during the firſt ſix weeks they received only one viſit from them, two men ſtrolling one evening into the camp, and remaining in it

Urceola Elastica. Plate XLII.



it for about half an hour. They appeared to admire whatever they saw; and after receiving a hatchet (of the use of which the eldest instantly and curiously shewed his knowledge, by turning up his foot and sharpening a piece of wood on the sole with the hatchet) took their leave, apparently well pleased with their reception. The fishing boats also frequently reported their having been visited by many of these people when hauling the seine; at which labour they often assisted with cheerfulness, and in return were generally rewarded with a part of the fish taken.

The first labour in which the convicts were employed was that of building huts; and for this purpose it was found necessary to divide them into gangs, and to appoint an overseer to each, who should see that the proper quantity of work was performed. The provisions were distributed by a weekly ration, and to each man were allowed 7lb. of biscuit, 1lb. of flour, 7lb. of beef or 4lb. of pork, 3 pints of pease, and 6 ounces of butter. To the female convicts two thirds of this ration were allowed. This was the full ration, which, in many instances, it became necessary to reduce; and once, in consequence of the delay of transports with a supply, the convicts were put on an allowance of which flesh meat constituted no part.

The temporary huts in which the colonists lived, for some time after their arrival, were formed principally of the cabbage tree. With this the sides and ends were filled; the posts and plates being made of the pine; and the whole was plastered with clay. The roofs were generally thatched with the grass of the gumrush; though some were covered with clay, but several of these failed; the weight of the clay and rain soon destroying them. In a short time they applied themselves to the burning of bricks; by which their habitations soon became much more lasting and comfortable. The progress of the colony, however, towards that degree of convenience which was within its reach, was greatly impeded by the incorrigible vices of those who principally composed it. Drunkenness, theft, robbery, and unconquerable laziness, continued to mark the character of the great body of the convicts. Though to fly from the colony, and venture into the interior of the country, was inevitable death in the form of famine or of murder, yet such was the invincible antipathy to labour manifested by some of those people, that they often fled to the woods, from which they seldom returned; some dying of hunger, and some being sacrificed by the natives. Disinclination to labour produced here, as elsewhere, its natural effect—robbery

In the month of May 1788, a lad of 17 years of age was tried, convicted, and executed, for breaking open a tent belonging to one of the transport ships; several others were taken into custody in that month for various thefts and burglaries, and two were afterward tried and executed. One of these had absconded, and lived in the woods for 19 days, subsisting by what he was able to procure by nocturnal depredations among the huts and stock of individuals. His visits for this purpose were so frequent and daring, that it became absolutely necessary to proclaim him an outlaw. By the negligence of one of those fellows who had been entrusted with the care of the cattle, the bull and four cows were lost: he left them in the fields, and returned to his hut to dine; and in the mean time they either strayed away or were driven off by the natives. Five years elapsed before these cattle were discovered wild, at a considerable distance up the country, and greatly multiplied.

The perpetration of crimes, chiefly theft and robbery, had become so prevalent before twenty months had passed since the colony was established, that it was necessary to think of a system of police. A plan was presented to the governor by a *convict*, which with some improvements was adopted on the 8th of August 1789. The following are the heads of the arrangement.

The settlement was divided into four districts, over each of which was placed a watch consisting of three persons, one principal and two subordinate watchmen. These being selected from among those convicts whose conduct and character had been unexceptionable since their landing, were vested with authority to patrole at all hours in the night, to visit such places as might be deemed requisite for the discovery of any felony, trespass, or misdemeanor, and to secure for examination all persons that might appear to be concerned therein; for which purpose they were directed to enter any suspected hut or dwelling, or to use any other means that might appear expedient. They were required to detain and give information to the nearest guardhouse of any soldier or seaman who should be found straggling after the tattoo had been beat. They were to use their utmost endeavours to trace out offenders on receiving accounts of any depredation; and in addition to their night-duty, they were directed to take cognizance of such convicts as gamed, or sold or bartered their slops or provisions, and report them for punishment. A return of all occurrences during the night was to be made to the judge-advocate; and the military were required to furnish the watch with any assistance they might be in need of, beyond what the civil power could give them. They were provided each with a short staff, to distinguish them during the night, and to denote their office in the colony; and were instructed not to receive any stipulated encouragement or reward from any individual for the conviction of offenders, but to expect that negligence or misconduct in the execution of their trust would be punished with the utmost rigour. It was to have been wished, says Mr Collins, that a watch established for the preservation of public and private property had been formed of free people, and that necessity had not compelled us, in selecting the first members of our little police, to appoint them from a body of men, in whose eyes, it could not be denied, the property of individuals had never before been sacred But there was not any choice: The military had their line of duty marked out for them, and between them and the convict there was no description of people from whom overseers or watchmen could be provided. It might, however, be supposed, that among the convicts there must be many who would feel a pride in being distinguished from their fellows, and a pride that might give birth to a returning principle of honesty. It was hoped that the convicts whom we had chosen were of this description; some effort had become necessary to detect the various offenders who were prowling about with security under cover of the night; and the convicts who had any property were themselves interested in defeating such practices. They promised fidelity and diligence, from which the scorn of their fellow-prisoners should not induce them to swerve, and began with a cou-

confidence of fuch as the duty which they had themfelves offered to undertake.

A fpecies of difturber now infefted the colony, againft which the vigilance of a police could not guard. Rats, in immenfe numbers, had attacked the provifion ftores, and could be counteracted only by removing the provifions from one ftore to another. When their ravages were firft difcovered, it was found that eight cafks of flour were already deftroyed by thefe vermin. Such of thefe animals as efcaped the dogs, which were fet upon them, flew to the gardens of individuals, where they rioted on the Indian corn that was growing, and did confiderable mifchief.

Our author gives the moft melancholy account of the extreme fufferings of the early coloniits from want of provifions, and of the difeafes imported into the country by newcomers, who had either caught them on the voyage or brought them from England. The fettlers on *Norfolk Ifland* (fee *Encycl.*), to which New South Wales was a mother country, muft have been much more liable than that colony to fuffer from famine, had they not fometimes obtained a temporary fupply from a fource which was unknown at Sydney Cove. On a mountain in the ifland, to which had been given the name of *Mount Pitt*, they were fortunate enough to obtain, in an abundance almoft incredible, a fpecies of aquatic birds, anfwering the defcription of that known by the name of the *puffin*. Thefe birds came in from the fea every evening, in clouds literally darkening the air, and defcending on Mount Pitt, depofited their eggs in deep holes made by themfelves in the ground, generally quitting them in the morning, and returning to feek their fubfiftence in the fea. From two to three thoufand of thefe birds were often taken in a night. Their feeking their food in the ocean left no doubt of their own flefh partaking of the quality of that upon which they fed; but to people circumftanced as were the inhabitants on Norfolk Ifland, this leffened not their importance; and while any Mount Pitt birds (fuch being the name given them) were to be had, they were eagerly fought.

The firft fettler in New South Wales, who declared himfelf able to live on the produce of his farm, without any affiftance from the ftores, was James Rufe; who in April 179· relinquifhed his claim to any farther fhare of the public provifion. As a reward, the governor immediately put him in poffeffion of an allotment of 30 acres.

In the July of the fame year, the convicts whofe terms of tranfportation had expired were now collected, and by the authority of the governor informed, that fuch of them as wifhed to become fettlers in this country fhould receive every encouragement; that thofe who did not, were to labour for their provifions, ftipulating to work for 12 or 18 months certain: and that in the way of fuch as preferred returning to England no obftacles would be thrown, provided they could procure paffages from the mafters of fuch fhips as might arrive; but that they were not to expect any affiftance on the part of government to that end. The wifh to return to their friends appeared to be the prevailing idea, a few only giving in their names as fettlers, and none engaging to work for a certain time.

That the wifh to return home was ftrong indeed, and paramount to all other feelings, was evinced in a very melancholy inftance fome time before. A convict, an elderly man, was found dead in the woods, near the fettlement; who, on being opened, it appeared, had died from want of nourifhment; and it was found that he was accuftomed to deny himfelf even what was abfolutely neceffary to his exiftence, abftaining from his provifions, and felling them for money, which he was referving, and had fomewhere concealed, in order to purchafe his paffage to England when his time fhould terminate!

Of fome convicts whofe terms of tranfportation had expired, the governor eftablifhed a new fettlement in Auguft 1791, at a place which he called *Profpect Hill*, about twenty miles diftant from Sydney Cove; and another refidence was formed at the Ponds within three or four miles of the former. This made the fourth fettlement in the colony, exclufively of that at Norfolk Ifland.

About this time the governor received from England a public feal for the colony: on the obverfe of which were the king's arms and royal titles; and on the reverfe, emblematic figures fuited to the fituation of the people for whofe ufe it was defigned. The motto was "*Sic fortis Etruria crevit;*" and in the margin were the words "*Sigillum Nov. Camb. Auft.*" A commiffion alfo arrived, empowering him to remit abfolutely, or conditionally, the whole or any part of the term for which the felons fent to the colony might be tranfported. By this power he was enabled to beftow on fuperior honefty and induftry the moft valuable reward which, in fuch circumftances, they could receive.

In addition to the calamities under which the fettlement had fo often laboured from being reduced to very fhort allowance of provifions, and the frequency of the ordinary difeafes which were to be expected among a people fo fituated, a new malady of a very alarming nature was perceived about April 1792. Several convicts were feized with infanity; and as the major part of thofe who were vifited by this calamity were females, who, on account of their fex, were not haraffed with hard labour, and who in general fhared largely of fuch little comforts as were to be procured in the fettlement, it was difficult to affign a caufe for this diforder. It feems, however, to have been of fhort duration; for we hear not of it again during the period that Mr Collins's narrative comprehends.

About this time (1792) the colony had affumed fomething of an eftablifhed form. Brick huts were in hand for the convicts in room of the miferable hovels occupied by many, which had been put up at their firft landing, and in room of others which, from having been erected on fuch ground as was then cleared, were now found to interfere with the direction of the ftreets which the governor was laying out. People were alfo employed in cutting paling for fencing in their gardens. At a place called Paramatta, about 16 miles from Sydney Cove, fituated on a fmall river which runs into Port Jackfon, the people were employed, during the greateft part of the month of May, in getting in the maize and fowing wheat. A foundation for an hofpital was laid, a houfe built for the mafter carpenter, and roofs prepared for the different huts either building or to be built in future.

In December 1792, when Captain Phillip refigned the government, nearly five years from the foundation of

of the colony, there were in cultivation at the different ſettlements 1429 acres, of which 417 belonged to ſettlers; that is, 67 ſettlers, for there were no more, cultivated nearly half as much ground as was cultivated by the public labour of all the convicts; a ſtriking proof of the ſuperior zeal and diligence with which men exert themſelves when they have an intereſt in their labour. Of free ſettlers, whoſe exertions promiſed ſo fairly to promote the intereſts of the colony, ſeveral arrived from England in January 1793, and fixed themſelves in a ſituation which they called *Liberty Plains*. To one of theſe, Thomas Roſe, a farmer from Dorſetſhire, and his family of a wife and four children, 120 acres were allotted. The conditions under which theſe people agreed to ſettle were, "to have their paſſage provided by government (A); an aſſortment of tools and implements to be given to them out of the ſtores; that they ſhould be ſupplied with two years proviſions; that their lands ſhould be granted free of expence; the ſervice of convicts alſo to be aſſigned to them free of expence; and that thoſe convicts ſhould be ſupplied with two years rations and one year's clothing."

Among the great difficulties with which this infant eſtabliſhment had to ſtruggle, not the leaſt was that of procuring cattle. Of thoſe which were embarked in England and other places for the colony, a very ſmall proportion only arrived; for of 15 bulls and 119 cows, which had been embarked for Botany Bay, only 3 bulls and 28 cows were landed at the ſettlement. It was not until the arrival of the Endeavour, Captain Bampton, in 1795, that the mode of conveying cattle to the colony without material loſs was diſcovered. In that veſſel, out of 130 head which he embarked at Bombay, one cow only died on the paſſage, and that too on the day before his arrival.

The ſcarcity of cattle naturally raiſed their price. Even after this laſt importation, an Engliſh cow in calf ſold for L.80.

Notwithſtanding the various obſtacles which induſtry had met in the cultivation of this ſettlement, it yet made conſiderable advances; for in October 1793, the value of land had ſo riſen, that one ſettler ſold his allotment of 30 acres for as many pounds; and one farm, with the houſe, &c. ſold for L.100. The value of ground, indeed, was conſiderably enhanced by government agreeing to purchaſe the redundance of the produce of the ſettlers at fixed prices. Wheat properly dried and cleanſed was received from the ſettlers at Sydney, by the commiſſary, at 10s. per buſhel. Some cultivators, however, had deviſed another mode of diſpoſing of their corn. One of them, whoſe ſituation was near Parramatta, having obtained a ſmall ſtill from England, found it more advantageous to draw an ardent diabolical ſpirit from his wheat, than to lend it to the ſtores. From one buſhel of wheat he obtained nearly five quarts of ſpirit, which he ſold or paid in exchange for labour, at the rate of five or ſix ſhillings per quart. A better uſe was made of grain by another ſettler; who, having a mill, ground it, and procured 44lb. of good flour, from a buſhel of wheat taken at 59lb. This flour he ſold at 4d. per lb.

By a return of the number of perſons in New South Wales and Norfolk Iſland in April 1794, it appeared that there were in all 4414, including women and children; the annual expence of whom, to the mother-country, Mr Collins eſtimates at L.161,101. Rapid ſtrides, however, were at that time making towards independence, if not towards an ability of repaying to England a part of what the ſettlement had coſt her. Already the colony lived on grain of its own growth, and an increaſe of live ſtock was become almoſt certain. There were now 4665 acres of ground cleared for cultivation; more than half of which had been effected by thoſe who had become ſettlers in the courſe of fifteen months.

To this ſpirit of improvement ſuch a check was given in September 1794, that not more than a third of government ground, and a fifth of ground belonging to individuals, was in cultivation 1795. As this event has been miſrepreſented, we ſuſpect purpoſely, by ſome of our journaliſts, we ſhall give the true account of it in the words of Mr Collins himſelf

"The Francis ſchooner (ſays he) returned from Norfolk, having been abſent about eight weeks and three days. From Mr King, who commanded in that iſland, we learned that his harveſt had been prodigiouſly productive. He had purchaſed from the firſt crops, which the ſettlers had brought to market, upwards of 11,000 buſhels of maize; and bills for the amount were drawn by him in favour of the reſpective ſettlers; but requiring the ſanction of the Lieutenant governor, they were now ſent to Port Jackſon. Mr King had been partly induced to make this proviſional kind of purchaſe, under an idea, that the corn would be acceptable at Port-Jackſon, and alſo in compliance with the conditions on which the ſettlers had received their reſpective allotments under the regulations of Governor Phillip; that is to ſay, that their overplus grain ſhould be purchaſed at a fair market price. Being, however, well ſtocked with that article already, the Lieutenant governor did not think himſelf juſtifiable in putting the crown to ſo great an expence (nearly L.3000 Sterling), and declined accepting the bills." This naturally excited ſome diſcontents in Norfolk Iſland, and one or two ſettlers gave up their farms; but immediately on the arrival of Governor Hunter, he paid for the corn, and tranquillity was reſtored to the iſland.

Though ſeveral quarrels had occurred between the natives and individuals among the coloniſts, yet it was ſuppoſed that our people were in general the aggreſſors. The governor had taken much pains to inſpire the natives with confidence, and had in a great meaſure ſucceeded. To theft they were naturally and irreſiſtibly inclined; but, like other ſavages, they ſeemed unconſcious of the crime, and were ſeldom deterred by detection from mixing with the coloniſts. At a ſettlement which had early been formed at a river called the *Hawkeſbury* (and at which, cultivation having gone on well, there was, in courſe, much grain to ſtimulate to depredation), the natives aſſumed a more formidable appearance.

"At that ſettlement (ſays Mr Collins) an open war ſeemed

Wales.

(A) Government paid for the paſſage of each perſon above ten years of age L.8, 8s. and one ſhilling per day for victualling them.

Wales. seemed about this time to have commenced between the natives and the settlers: and word was received overland, that two people were killed by them; one a settler of the name of Wilson, and the other a freeman, one William Thorp, who had hired himself to this Wilson as a labourer. The natives appeared in large bodies, men, women, and children, provided with blankets and nets to carry off the corn, of which they appeared as fond as the natives who lived among us, and seemed determined to take it whenever and wherever they could meet with opportunities. In their attacks they conducted themselves with much art; but where that failed they had recourse to force; and on the least appearance of resistance made use of their spears or clubs. To check at once, if possible, these dangerous depredators, Captain Paterson directed a party of the corps to be sent from Paramatta, with instructions to destroy as many as they could meet with of the wood tribe (Bè-diagal); and, in the hope of striking terror, to erect gibbets in different places, whereon the bodies of all they might kill were to be hung. It was reported that several of these people were killed in consequence of this order; but none of their bodies being found (perhaps if any were killed they were carried off by their companions), the number could not be ascertained. Some prisoners, however, were taken, and sent to Sydney; one man (apparently a cripple), five women, and some children. One of the women, with a child at her breast, had been shot through the shoulder, and the same shot had wounded the babe. They were immediately placed in a hut near our hospital, and every care taken of them that humanity suggested. The man was said, instead of being a cripple, to have been very active about the farms, and instrumental in some of the murders which had been committed. In a short time he found means to escape, and by swimming reached the north shore in safety; whence, no doubt, he got back to his friends. Captain Paterson hoped, by detaining the prisoners and treating them well, that some good effect might result; but finding, after some time, that coercion, not attention, was more likely to answer his ends, he sent the women back. While they were with us, the wounded child died, and one of the women was delivered of a boy, which died immediately. On our withdrawing the party, the natives attacked a farm nearly opposite Richmond Hill, belonging to one William Rowe, and put him and a very fine child to death; the wife, after receiving several wounds, crawled down the bank, and concealed herself among some reeds half immersed in the river, where she remained a considerable time without assistance: being at length found, this poor creature, after having seen her husband and her child slaughtered before her eyes, was brought into the hospital at Paramatta, where she recovered, though slowly, of her wounds."

By the vigorous measures which were adopted, the colony, towards the close of 1796, had acquired a degree of strength which seemed to ensure its future prosperity. Not only the necessary edifices were raised for the habitations of its people, but some for the purposes of religion, amusement, &c. A playhouse had been erected at the expence of some persons who performed in it for their own emolument, and who admitted auditors at one shilling each. A convenient church had been built, a printing-press had been set up, the civil court was open for the recovery of debts by action and for proving wills, licences had been issued to regulate the sale of spirits, and passage-boats were established for the convenience of communication between the different settlements. In the houses of individuals were to be found most of the comforts, and not a few of the luxuries, of life; and, in a word, the former years of famine, toil, and difficulty, were now exchanged for those of plenty, ease, and pleasure.

The quantity of ground at this time in cultivation was 5410 acres; of which 2547 were occupied by settlers. The number of persons in New South Wales and its dependencies amounted to 4848. The price of labour, however, compared with the prices of provisions (as given in Mr Collins's Tables), does not appear so high as to enable the workman to live very comfortably. He who receives but three shillings for his day's work, and gives two shillings for a pound of mutton, fifteen pence for a pound of pork, and half of that sum for a pound of flour, will scarcely derive from his mere labour the support necessary for a family.

That many things are yet wanted to give full effect to the advantages which the colony now enjoys, M Collins declares in the following paragraph, with which he concludes his account:

"The want at this time of several public buildings in the settlement has already been mentioned. To this want must be added, as absolutely necessary to the well-being and comfort of the settlers, and the prosperity of the colony in general, that of a public store, to be opened on a plan, though not exactly the same, yet as liberal as that of the Island of St Helena, where the East India Company issue to their own servants European and Indian goods at 10 *per cent.* advance on the prime cost. Considering our immense distance from England, a greater advance would be necessary; and the settlers and others would be well satisfied, and think it equally liberal, to pay 50 *per cent.* on the prime cost of all goods brought from England; for at present they pay never less than 100, and frequently 1000, *per cent.* on what they have occasion to purchase. It may be supposed that government would not choose to open an account, and be concerned in the retail of goods; but any individual would find it to his interest to do this, particularly if assisted by government in the freight; and the inhabitants would gladly prefer the manufactures of their own country to the sweepings of the Indian bazars.

"The great want of men in the colony must be supplied as soon as a peace shall take place; but the want of respectable settlers may, perhaps, be longer felt; by these are meant men of property, with whom the gentlemen of the colony could associate, and who should be thoroughly experienced in the business of agriculture. Should such men ever arrive, the administration of justice might assume a less military appearance, and the trial by jury, ever dear and most congenial to Englishmen, be seen in New South Wales."

There is, however, one serious difficulty which the colony has not yet overcome, and which, until it be overcome, will certainly prevent such men from settling in New South Wales. Till some staple commodity can be raised for exportation, industrious free settlers will never be tempted to emigrate from Europe to a country where their industry cannot procure the comforts as well

well as the necessaries of life. The American colonies, in their infancy, did not labour under this disadvantage. Tobacco soon became, and still continues to be, an article of such importance, that its cultivation afforded the trans-atlantic farmer a ready exchange for European commodities; whilst in New South Wales there seems to be no vegetable production of much value, except New Zealand hemp, which is produced indeed in great abundance in Norfolk Island, and which Captain Cook long ago pointed out as an article of great importance to the British navy. This is indeed a valuable plant, and grows in all the cliffs of the island, where nothing else will grow, in sufficient abundance to give constant employment to 500 people; yet when Mr Collins left the settlement, there was no more than one loom on the island, and the flay or reed was designed for coarse canvas; nor did they possess a single tool required by flax-dressers or weavers beyond the poor substitutes which they were obliged to fabricate for themselves. In this defect of necessaries for the manufacture, only 18 people could be employed in it; and of these the united labour in a week produced 16 yards of canvas, of the size called N° 7.

Besides a useful manufactory of this plant, which certainly might be established, the colony appears to possess several important advantages. From Mr Collins's narrative, it appears probable that a seal and perhaps a whale fishery might be established with a fair prospect of success; good rich earth is found near Sydney Cove; there are immense strata of coal in the southern part of New Holland; Norfolk Island abounds with lime; and vast quantities of shells, which answer the same purpose, have been found on the main-land. Though the wood in general be not of a durable kind, it appears that there is some good timber near the Hawkesbury river; and at Norfolk Island and New Zealand it is remarkably fine.

* WALPOLE (Horace, Earl of Orford), was the youngest son of the celebrated Sir Robert Walpole, afterwards Earl of Orford, by his first wife, Catharine, daughter of Robert Shorter, Esq; of Bybrook in Kent. He was born 1716; and was educated, first at Eton school, and afterwards at Cambridge. At Eton he formed an intimate acquaintance with the celebrated poet Gray; and they went together on the tour of Europe, in the years 1739, 1740, and 1741. Unhappily they had a dispute in the course of their travels, which produced a separation.

Mr Walpole was able to make a splendid figure during the remainder of his destined course; but poor Gray, after the separation, was obliged to observe a very severe economy. "This difference arose from the difference of their tempers: the latter being, from his earliest years, curious, pensive, and philosophical; the former, gay, lively, and inconsiderate. This, therefore, occasioned their separation at Reggio. Mr Gray went before him to Venice; and staying there till he could find means of returning to England, he made the best of his way home, repassing the Alps, and following almost the same rout, through France, which he had before gone to Italy. In justice to the memory of so respectable a friend, Mr Walpole (says Mr Mason, Life of Gray, 4to, p. 41.) enjoins me to charge him with the chief blame in their quarrel, confessing that more attention, complaisance, and deference, to a warm friendship, and superior judgment and prudence, might have prevented a rupture that gave much uneasiness to them both, and a lasting concern to the survivor; though in the year 1744 a reconciliation was effected between them, by a lady who wished well to both parties."—This event took place after their return to England; but the *wound* in their friendship left a *scar* that never was totally effaced.

We do not, indeed, think that Horace Walpole and Mr Gray were formed, either by nature or by habits, to continue long in a state of intimate friendship. Gray appears to have been a man of the purest moral principles, a friend to religion, pensive, and at least sufficiently conscious of his intellectual powers and intellectual attainments. Walpole's morality was certainly of a looser kind; he seems to have had no religion; he was often unseasonably gay; and to an equal share of intellectual pride, though without equal reason, he added the pride of birth. It can therefore excite no surprise that a man of Gray's independent spirit could not bear the supercilious freaks of such a character.

Mr Walpole was nominated to represent the city of Norwich, when his father visited it July 3d, 1733, having acquired consequence, not only as the son of the minister, but as having attended the Prince of Orange to England in that year. He was chosen member for Collington, in Cornwall, in the parliament which met June 25th, 1741; was a second time in parliament as representative for Castle Rising, in Norfolk, in 1747; and for King's Lynn in 1754 and 1761; and, at the expiration of that parliament, he finally retired from the stage of politics, and confined himself wholly to literary pursuits. He held to his death the office of usher of his Majesty's exchequer, comptroller of the pipe, and clerk of the estreats. Upon the death of his nephew, George, third Earl of Orford, 1791, he succeeded to the title and estates; but that event made so little alteration in his mode of living, that we know not whether he ever took his seat in the house of peers. During almost the whole course of his life he was the victim of the gout, which at last reduced him to a cripple: but it never impaired his faculties; and, to the very moment of death, his understanding seemed to bid defiance to the shock of Nature. He died at his house in Berkesley Square, in 1796, having just entered his 80th year; and was interred in the family vault at Houghton, in a private manner, agreeably to his particular directions.

Horace, Lord Orford, was never married, and, by one of his biographers, his chief mistress through life is said to have been the muse. It is certain that he devoted the greater part of his life to belles lettres and virtú, though he ridiculously affected, in his letters to his friends, to despise learning and learned men, for which he was very properly reprimanded both by Gray and Hume. It was an affectation peculiarly absurd in him, who was constantly publishing something, and who wrote with uncommon acrimony against all who presumed to call in question the fidelity of the picture which he had drawn of Richard III. or indeed to controvert any of his opinions. Hence his antipathy to Johnson, because he was a tory, a Christian, and a rigid moralist; whilst he himself was a whig, an infidel, and such a moralist as could retail, without blushing, all the scandalous anecdotes, whether true or false, of that august family, from

whom he acknowledged his whole fortune to be derived. He had, indeed, another reason for disliking Johnson. Lord Orford shone in conversation, and surpassed all his contemporaries in that kind of talk, which, without dazzling by its wit, always delighted; while Johnson, when roused, knocked down, as by a flash of lightning, his Lordship, and every one else who had the confidence before him to talk profanely. Johnson's wit was original: Lord Orford's consisted of ludicrous stories and of literary and political anecdotes. His works, of which by far the most valuable part has long been in the hands of the public, were collected in 1798, and published in five volumes, 4to. They resemble his conversation, being rather amusing than profound or instructive.

WARING (Edward, M.D.), Lucasian Professor of Mathematics in the university of Cambridge, was the son of a wealthy farmer, of the Old Heath, near Shrewsbury. The early part of his education he received at the free school in Shrewsbury; whence he removed to Cambridge, and was admitted on the 24th of March 1753 a member of Magdalen college. Here his talents for abstruse calculation soon developed themselves, and, at the time of taking his degree, he was considered as a prodigy in those sciences which make the subject of the bachelor's examination. The name of Senior Wrangler, or the first of the year, was thought scarcely a sufficient honour to distinguish one who so far outshone his contemporaries; and the merits of John Jebb were sufficiently acknowledged, by being the second in the list. Waring took his first, or bachelor's degree, in 1757, and the Lucasian Professorship became vacant before he was of sufficient standing for the next, or master's degree, which is a necessary qualification for that office. This defect was supplied by a royal mandate, through which he became master of arts in 1760; and shortly after his admission to this degree, the Lucasian Professor.

The royal mandate is too frequently a screen for indolence; and it is now become almost a custom, that heads of colleges, who ought to set the example in discipline to others, are the chief violaters of it, by making their office a pretext for taking their doctor's degree in divinity, without performing those exercises which were designed as proofs of their qualifications. Such indolence cannot be imputed to Waring; yet several circumstances, previous to his election into the professorial chair, discovered that there was, at least, one person in the university who disapproved of the anticipation of degrees by external influence.—Waring, before his election, gave a small specimen of his abilities, as proof of his qualification for the office which he was then soliciting; and a controversy on his merits ensued: Dr Powell, the master of St John's college, attacking, in two pamphlets, the Professor; and his friend, afterwards Judge Wilson, defending. The attack was scarcely warranted by the errors in the specimen; and the abundant proofs of talents in the exercise of the professorial office are the best answers to the sarcasms which the learned divine amused himself in casting on rising merit. An office held by a Barrow, a Newton, a Whiston, a Cotes, and a Sanderson, must excite an ingenuous mind to the greatest exertions; and the new Professor, whatever may have been his success, did not fall behind any of his predecessors, in either zeal for the science, or application of the powers of his mind, to extend its boundaries. In 1762, he published his Miscellanea Analytica; one of the most abstruse books written on the abstrusest parts of algebra. This work extended his fame over all Europe. He was elected, without solicitation on his part, member of the societies of Bononia and Gottingen; and received flattering marks of esteem from the most eminent mathematicians at home and abroad. The difficulty of this work may be presumed from the writer's own words, "I cannot say that I know any one who thought it worth while to read through the whole, and perhaps not the half of it."

Waring.

Mathematics did not, however, engross the whole of his attention. He could dedicate some time to the study of his future profession; and in 1767, he was admitted to the degree of doctor of physic; but, whether from the incapacity of uniting together the employments of active life with abstruse speculation, or from the natural diffidence of his temper, for which he was most peculiarly remarkable; the degree which gave him the right of exercising his talents in medicine was to him merely a barren title. Indeed he was so embarrassed in his manners before strangers, that he could not have made his way in a profession in which so much is done by address; and it was fortunate that the case of his circumstances permitted him to devote the whole of his time to his favourite pursuit. His life passed on, marked out by discoveries, chiefly in abstract science; and by the publication of them in the Philosophical Transactions, or in separate volumes, under his own inspection. He lived some years after taking his doctor's degree, at St Ives, in Huntingdonshire. While at Cambridge he married—quitted Cambridge with a view of living at Shrewsbury; but the air or smoke of the town being injurious to Mrs Waring's health, he removed to his own estate at Plaisley, about 8 miles from Shrewsbury, where he died in 1797, universally esteemed for inflexible integrity, modesty, plainness, and simplicity of manners. They who knew the greatness of his mind from his writings looked up to him with reverence everywhere; but he enjoyed himself in domestic circles with those chiefly among whom his pursuits could not be the object either of admiration or envy. The outward pomp which is affected frequently in the higher departments in academic life, was no gratification to one whose habits were of a very opposite nature; and he was too much occupied in science to attend to the intrigues of the university. There, in all questions of science, his word was the law; and at the annual examination of the candidates for the prize instituted by Dr Smith, he appeared to the greatest advantage. The candidates were generally three or four of the best proficients in the mathematics at the previous annual examination for the bachelor's degree, who were employed from nine o'clock in the morning to ten at night, with the exception of two hours for dinner, and twenty minutes for tea, in answering, *viva voce*, or writing down answers to the professor's questions, from the first rudiments of philosophy to the deepest parts of his own and Sir Isaac Newton's works. Perhaps no part of Europe affords an instance of so severe a process; and there was never any ground for suspecting the Professor of partiality.

lity. The zeal and judgment with which he performed this part of his office cannot be obliterated from the memory of those who passed through his fiery ordeal

Wishing to do ample justice to the talents and virtue of the Professor, we feel ourselves somewhat at a loss in speaking of the writings by which alone he will be known to posterity. He is the discoverer, according to his own account, of nearly 400 propositions in the analytics. This may appear a vain glorious boast, especially as the greater part of those discoveries are likely to sink into oblivion; but he was, in a manner, compelled to make it by the insolence of Lalande, who, in his life of Condorcet, asserts that, in 1764, there was no first-rate analyst in England In reply to this assertion, the Professor, in a letter to Dr Maskelyne, first mentions, with proper respect, the inventions and writings of Harriot, Briggs, Napier, Wallis, Halley, Bruncker, Wren, Pell, Barrow, Mercator Newton, De Moivre, Maclaurin, Cotes, Stirling, Taylor, Simpson, Emerson, Landen, and others; of whom Emerson and Landen were living in 1764. He then gives a fair and full detail of his own inventions, of which many were published anterior to 1764; and concludes his letter in these words.

"I know that Mr Lalande is a first-rate astronomer, and writer of astronomy; but I never heard that he was much conversant in the deeper parts of mathematics; for which reason I take the liberty to ask him the following questions:

"Has he ever read or understood the writings of the English mathematicians: and, as the question comes from me, I subjoin, particularly of mine? If the answer be in the negative, as it is my opinion, if his answer be the truth, that it will, then there is an end of all further controversy;—but if he asserts that he has, which is more than Condorcet did by his own acknowledgment, then he may know, from the enumeration of inventions made in the prefaces, with some subsequent ones added, that they are said to amount to more than 400 of one kind or other. Let him try to reduce those to as low a number as he can, with the least appearance of candour and truth; and then let him compare the number with the number of inventions of any French mathematician or mathematicians, either in the present or past times, and there will result a comparison (if I mistake not) not much to his liking; and, further, let him compare some of the first inventions of the French mathematicians with some of the first contained in my works, both as to utility, generality, novelty, difficulty, and elegance, but wisely as to utility, there is little contained in the deep parts of any science; he will find their difficulty and novelty from his difficulty of understanding them, and his never having read any thing similar before; their generality, by the application of them; principles of elegance will differ in different persons.—I must say, that he will probably not find the difference expected. After or before this inquiry is instituted for mine, let him perform the same for the other English mathematicians; and when he has completed such inquiries, and not before, he will become a judge of the justice of his assertion; but I am afraid that he is not a sufficient adept in these studies to institute such inquiries; and if he was, such inquiries are invidious, troublesome, and of small utility."

By mathematical readers this account, which was not published by the Professor himself, is allowed to be very little, if at all, exaggerated. Yet if, according to his own confession, "few thought it worth their while to read even half of his works," there must be some grounds for this neglect, either from the difficulty of the subject, the unimportance of the discoveries, or a defect in the communication of them to the public. The subjects are certainly of a difficult nature, the calculations are abstruse; yet Europe contained many persons not to be deterred by the most intricate theorems. Shall we say then, that the discoveries were unimportant? If this were really the case, the want of utility would be a very small disparagement among those who cultivate science with a view chiefly to entertainment and the exercise of their rational powers. We are compelled, then, to attribute much of this neglect to a perplexity in style, manner, and language; the reader is stopped at every instant, first to make out the writer's meaning, then to fill up the chasm in the demonstration. He must invent anew every invention; for, after the enunciation of the theorem or problem, and the mention of a few steps, little assistance is derived from the Professor's powers of explanation. Indeed, an anonymous writer, certainly of very considerable abilities, has aptly compared the works of Waring to the heavy appendages of a Gothic building, which add little of either beauty or stability to the structure.

A great part of the discoveries relate to an assumption in algebra, that equations may be generated by multiplying together others of inferior dimensions. The roots of these latter equations are frequently terms called *negative* or *impossible*; and the relation of these terms to the coefficients of the principal equation is a great object of inquiry. In this art the professor was very successful, though little assistance is to be derived from his writings in looking for the real roots. We shall not, perhaps, be deemed to depreciate his merits, if we place the series for the sum of the powers of the roots of any equation among the most ingenious of his discoveries; yet we cannot add, that it has very usefully enlarged the bounds of science, or that the algebraist will ever find occasion to introduce it into practice. We may say the same on many ingenious transformations of equations, on the discovery of impossible roots, and similar exertions of undoubtedly great talents. They have carried the assumption to its utmost limits; and the difficulty attending the speculation has rendered persons more anxious to ascertain its real utility; yet they who reject it may occasionally receive useful hints from the Miscellanea Analytica.

The first time of Waring's appearing in public as an author was, we believe, in the latter end of the year 1759, when he published the first chapter of the Miscellanea Analytica, as a specimen of his qualifications for the professorship; and this chapter he defended, in a reply to a pamphlet, intitled, "Observations on the First Chapter of a book called Miscellanea Analytica." Here the Professor was strangely puzzled with the common paradox, that nothing divided by nothing may be equal to various finite quantities, and has recourse to unquestionable authorities in proof of this position. The names of Maclaurin, Sanderson, De Moivre, Bernoulli, Monmort, are ranged in favour of his opinion: But Dr Powell was not so easily convinced, and returns to the charge in defence of the Observations; to which the

Waring. Professor replied in a letter to the Rev. Dr Powell, Fellow of St John's college, Cambridge, in answer to his Observations, &c. In this controversy, it is certain that the Professor gave evident proofs of his abilities; though it is equally certain that he followed too implicitly the decisions of his predecessors. No apparent advantage, no authority whatever, should induce mathematicians to swerve from the principles of right reasoning, on which their science is supposed to be peculiarly founded. According to Maclaurin, Dr Waring, and others, If $P = \frac{a-x}{a^2-x^2}$, then, when $x = a$, P is equal to $\frac{1}{2a}$; for, say they, $\frac{a-x}{a^2-x^2}$ is equal to $\frac{a-x}{a-x} \times \frac{1}{a+x}$; that is, when x is equal to a, $P = \frac{1}{a+x}$, or $\frac{1}{2a}$. But when x is equal to a, the numerator and denominator of the fraction $\frac{a-x}{a^2-x^2}$ are both, in their language, equal to nothing. Therefore, nothing divided by nothing is equal to $\frac{1}{2a}$. In the same manner, $\frac{a-x}{a^3-x^3} = \frac{1}{a^2+ax+x^2} \times \frac{a-x}{a-x}$, which, when x is equal to a, becomes $\frac{1}{3a^2}$. Therefore, nothing divided by nothing is equal to $\frac{1}{3a^2}$, or $\frac{1}{3a^2} = \frac{1}{2a}$; that is, $\frac{1}{3a} = \frac{1}{2}$; which is absurd. But we need only trace back our steps to see the fallacy in this mode of reasoning. For P is equal to some number multiplied into $\frac{a-x}{a-x}$; that is, when x is equal to a, P is equal to some number multiplied into nothing, and divided by nothing; that is, P is, in that case, no number at all. For $a-a$ cannot be divided by $a-x$ when x is equal to a, since, in that case, $a-x$ is no number at all.

If, in the beginning of his career, the Professor could admit such paralogisms into his speculations, and the writings of the mathematicians, for nearly a century before him, may plead in his excuse, we are not to be surprised that his discoveries should be built rather on the assumptions of others than on any new principles of his own. Acquiescing in the strange notion, that nothing could be divided by nothing, and produce a variety of numbers, he as easily adopted the position, that an equation has as many roots as it has dimensions.—Thus 2 and — 4 are said to be roots of the equation $x^2 + 2x = 8$, though 4 can be the root only of the equation; $x^2 - 2x = 8$, which differs so materially from the preceding, that in one case $2x$ is added, in the other case it is subtracted from x^2.

Allowances being made for this error in the principles, the deductions are, in general, legitimately made; and any one, who can give himself the trouble of demonstrating the propositions, may find sufficient employment in the Professor's analytics. Perhaps it will be sufficient for a student to devote his time to the simplest case $x^n \pm 1 = 0$; and when he has found a few thousand roots of + 1 and — 1, the publication of them may afford to posterity a strong proof of the ingenuity of their predecessors, and the application of Waring. the powers of their mind to useful and important truths. In this exercise may be consulted the method given by the Professor, of finding a quantity, which, multiplied into a given irrational quantity, will produce a rational product, or consequently exterminate irrational quantities out of a given equation; but if an irrational quantity cannot come into an equation, the utility of this invention will not be admitted without hesitation.

The "Proprietates Algebraicarum Curvarum," published in 1772, necessarily labour under the same defects with the Miscellanea Analytica, the Meditationes Algebraicæ, published in 1770, and the Meditationes Analyticæ, which were in the press during the years 1773, 1774, 1775, 1776. These were the chief and the most laborious works edited by the Professor; and in the Philosophical Transactions is to be found a variety of papers, which alone would be sufficient to place him in the first rank in the mathematical world. The nature of them may be seen from the following catalogue.

Vol LIII. p. 294, Mathematical Problems.—LIV. 193. New Properties in Conics.—LV. 143. Two Theorems in Mathematics.—LXIX Problems concerning Interpolations.—86. A General Resolution of Algebraical Equations —LXXVI. 81. On Infinite Series. LXXVII. 71. On Finding the Values of Algebraical Quantities by Converging Serieses, and Demonstrating and Extending Propositions given by Pappus and others.—LXXVIII. 67. On Centripetal Forces.—*Ib.* 588. On some Properties of the Sum of the Division of Numbers.—LXXIX. 166 On the Method of Correspondent Values, &c.—*Ib.* 185. On the Resolution of Attractive Powers.—LXXXI. 146. On Infinite Serieses.—LXXXIV. 385—415. On the Summation of those Serieses whose general term is a determinate function of z, the distance of the term of the Series.

For these papers, the Professor was, in 1784, deservedly honoured by the Royal Society with Sir Godfrey Copley's medal; and most of them afford very strong proofs of the powers of his mind, both in abstract science, and the application of it to philosophy; though they labour, in common with his other works, under the disadvantage of being clothed in a very unattractive form. The mathematician, who has resolution to go through them, will not only add much to his own knowledge, but be usefully employed in dilating on those articles for the benefit of the more general reader. We might add in this place, a work written on morals and metaphysics in the English language; but as a few copies only were presented to his friends, and it was the Professor's wish that they should not have a more extensive circulation, we shall not here enlarge upon its contents.

In the mathematical world, the life of Waring may be considered as a distinguished æra. The strictness of demonstration required by the ancients had gradually fallen into disuse, and a more commodious, though almost mechanical mode by algebra and fluxions took its place, and was carried to the utmost limit by the Professor. Hence many new demonstrations may be attributed to him, but 400 discoveries can scarcely fall to the lot of a human being. If we examine thoroughly those which our Professor would distinguish by such names, we shall find many to be mere deductions, o-

thers, as in the solution of biquadratics, anticipated by former writers But if we cannot allow to him the merit of so inventive a genius, we must applaud his assiduity; and, distinguished as he was in the scientific world, the purity of his life, the simplicity of his manners, and the zeal which he always manifested for the truths of the Gospel, will intitle him to the respect of all who do not esteem the good qualities of the heart inferior to those of the head.

WARTON (Joseph, D. D.) was born either towards the end of the year 1721, or in the beginning of the year 1722. He was the eldest son of Thomas Warton, B. D. who had been fellow of Magdalen College, Oxford; poetry professor from the year 1718 to 1728, and vicar of Basingstoke in Hampshire, and of Cobham in Surrey. Where the subject of this memoir was born we have not learned, though, were we to hazard a conjecture, we would say that it was in Oxford, as his father probably resided in that city during his professorship.

Our knowledge of the private history of Dr Warton is indeed extremely limited. We do not even know at what school, or in what college, he was educated; tho' it was probably at Winchester school, and certainly in some of the colleges in the university of Oxford For many years, he was successively under and upper master of Winchester college; but resigned the last of these offices when he found the infirmities of age coming upon him; and was succeeded by Dr Goddard the present excellent master. He was likewise prebendary of the cathedral church of Winchester, and rector of Wickham in Hampshire, where he died, aged 78.

His publications are few, but valuable. A small collection of poems, without a name, was the first of them, and contained the Ode to Fancy, which has been so much and so deservedly admired. They were all of them afterwards printed in Dodsley's collection. He was also a considerable contributor to the Adventurer, published by Dr Hawkesworth; and all the papers which contain criticisms on Shakespeare were written by him and his brother Thomas Warton, the subject of the next article.

The first volume of his Essay on the Life and Writings of Pope was published, had passed through several editions, and an interval of between 20 and 30 years had elapsed, before he gave a second volume of that elegant and instructive work to the world. He had not only meditated, but had collected materials for a literary history of the age of Leo X.; and proposals were actually in circulation for a work of that kind; but it is probable that the duties of his station did not leave him the necessary leisure for an undertaking which required years of seclusion and independence. His last and late work, which he undertook for the booksellers at a very advanced age, was an edition of Pope's Works, that has not altogether satisfied the public expectation. He retained, with great propriety indeed, many of the notes of Warburton; but is severely reprehended by the author of the Pursuits of Literature for suppressing the name of that prelate on his title-page, or including it only, as subordinate to his own, in the general expression *others*.

Dr Warton was cheerful in his temper, convivial in his disposition, of an elegant taste and lively imagination, with a large portion of scholarship, and a very general knowledge of the Belles Lettres of Europe; it may be presumed that Dr Warton possessed, beyond most men, the power of enlivening Classical Society. He was the intimate friend of Dr Johnson; was seen at the parties of Mrs Montague, as well as at the table of Sir Joshua Reynolds, and was an original member of the Literary Club. He possessed a liberal mind, a generous disposition, and a benevolent heart. He was not only admired for his talents and his knowledge, but was beloved for those qualities which are the best gifts of this imperfect state.

WARTON (Thomas), the brother of the preceding, was born in the year 1728. He received, as we have reason to believe, the first part of his education at Winchester; and at the age of 16 was entered a commoner of Trinity College, Oxford, under the tuition of Mr Geering. *Biog. Dict.*

He began his poetical career at an early age. In 1745, he published five pastoral eclogues, in which are beautifully described the miseries of war to which the shepherds of Germany were exposed. Not long after, in the year 1748, he had full scope afforded for the exertion of his genius. It is well known that Jacobite principles were suspected to prevail in the university of Oxford about the time of the rebellion in the year 1745. Soon after its suppression, the drunkenness and folly of some young men gave offence to the court, in consequence of which a prosecution was instituted in the court of King's Bench, and a stigma was fixed on the vice-chancellor and some other heads of colleges in Oxford. Whilst this affair was the general subject of conversation, Mr Malon published his "Isis," an elegy, in which he adverts to the above-mentioned circumstances. In answer to this poem, Mr Warton, encouraged by Dr Huddesford, the president of his college, published in 1749, "The Triumph of Isis," which excelled more in manly expostulation and dignity than the poem that produced it did in neatness and elegance. With great poetical warmth, and a judicious selection of circumstances, he characterises the eminent men who had been educated in Oxford, and draws a striking and animated portrait of Dr King, the celebrated public orator of that time. The whole poem shews the early maturity of his genius, and is finished with happy diligence.

In the year 1751, he succeeded to a fellowship of his college, and was thus placed in a situation easy and independent, and particularly congenial with his habits of retirement and study. In 1753, appeared his observations on "The Faery Queen of Spencer," in 8vo, a work which he corrected, enlarged, and republished, in two volumes crown octavo, in the year 1762. He sent a copy of the first edition to Dr Johnson, who, in a letter to him upon the subject, expressed this handsome compliment: "I now pay you a very honest acknowledgement for the advancement of the literature of our native country: you have shewn to all, who shall hereafter attempt the study of ancient authors, the way to success, by directing them to the perusal of the books which these authors had read."

In 1754, Dr Johnson visited Oxford for the first time after he had quitted residence there. Much of his time was spent with Mr Warton; and there appeared to have been a considerable degree of confidential intercourse between them upon literary subjects, and particularly on their own works. A pleasing account of

Warton.

this visit was communicated by Mr Warton to Mr Boswell, who has inserted it in his life of Johnson.

In 1755, Mr Warton exerted himself to procure for his friend the degree of master of arts by diploma from the university of Oxford; an honour which Johnson esteemed of great importance to grace the title page of his dictionary which he was about to publish. In 1756, Mr Warton was elected professor of poetry, which office he held for the usual term of ten years. His lectures were remarkable for elegance of diction and justness of observation. One of them, on the subject of pastoral poetry, was afterwards prefixed to his edition of Theocritus. In 1758, he contributed to assist Dr Johnson in the subscription to his edition of Shakespeare, and furnished him with some valuable notes. The Doctor remarks, in a letter to him, when soliciting his farther aid, "It will be reputable to my work, and suitable to your professorship, to have something of yours in my notes"

From the Clarendon press, in the year 1766, he published "Anthologiæ Græcæ, a Constantino Cephalâ conditæ, Libri tres," in 2 vols, 12mo. He concludes the learned and classical preface to this work, which is replete with accurate remarks on the Greek epigram, in the following words, which mark this publication for his own: "Vereor ut hactenus in plexendis florum corollis otium nimis longum pertraxerim. Proximè sequetur, cui nunc omnes operas et vires intendo, Theocritus. Interea quasi promulsidem convivii Lectoribus meis elegantias hasce vetustatis eruditæ propino."

In the year 1770, he conferred a similar honour up on the academical press by his edition of Theocritus, in 2 vols, 8vo. He undertook this work by the advice of Judge Blackstone, then fellow of All-Souls College, and an ardent promoter of every publication that was likely to do credit to the Clarendon press. This elaborate publication reflects no small credit on the learning, diligence, and taste of the editor.

In 1771, he was elected a fellow of the Antiquarian Society, and was presented by the Earl of Lichfield to the small living of Kiddington in Oxfordshire, which he held till his death. He likewise in this year published an improved account of "The Life of Sir Thomas Pope, founder of Trinity College, Oxford. In composing these memoirs, he bestowed much labour and research, and shewed great judgment in the arrangement of his materials. But possibly, in his ardour to pay a debt of gratitude, he has not sufficiently considered what was due to his own fame. The same strength of description and vigour of remark would have better suited the life of some eminently distinguished character, and extended the reputation of the author as a biographer beyond the circle of those academical readers who are influenced by the same feelings of veneration, respect, and gratitude which prompted Mr Warton to compose this work. The preface contains some excellent remarks on biographical writing.

The plan for a history of English poetry was laid by Pope, enlarged by Gray: but to bring an original plan nearly to a completion was reserved for the perseverance of Warton. In 1774 appeared his first volume; in 1778, the second and third; which brings the narrative down to the commencement of the reign of Elizabeth in 1581. This work displays the most singular combination of extraordinary talents and attainments. It unites the deep and minute researches of the antiquary with the elegance of the classical scholar and the skill of the practised writer. The style is vigorous and manly; the observations acute and just; and the views of the subject are extensive and accurate.

In 1777, he collected his poems into an octavo volume, containing miscellaneous pieces, odes, and sonnets. This publication may be considered in some measure original; there being only seven pieces that had before appeared, and near three times that number which were then printed for the first time.

In vindication of the opinion he had given in his second volume of "The History of Poetry," relative to the ingenious attempt of Chatterton to impose upon the public, he produced, in 1782, "An Inquiry into the Authenticity of the Poems attributed to Rowley." In this excellent pamphlet the principles of true criticism are laid down, an appeal is properly made to the internal evidence of the poems; and upon these grounds it is proved, in the most satisfactory manner, that they could not have been written by a monk of the fourteenth century.

The year 1785 brought him those distinctions which were no less honourable to those who conferred than to him who received them. He was appointed poet laureat on the death of Whitehead, and elected Camden professor of ancient history on the resignation of Dr Scott. His inauguration lecture was delivered in a clear and impressive manner from the professorial chair. It contained excellent observations on the Latin historians, and was written in a strong, perspicuous, and classical style. In his odes, the vigour and brilliancy of his fancy were not prostituted to an insipid train of courtly compliments: each presents an elegant specimen of descriptive poetry, and as all of them have only a slight relation to the particular occasion on which they were written, and have always a view to some particular and interesting subject, they will be perused with pleasure as long as this species of composition is admired.

He made occasional journeys to London to attend the literary club, of which he was some years a member; and to visit his friends, particularly Sir Joshua Reynolds. At his house he was sure to meet persons remarkable for fashion, elegance, and taste.

His last publication, except his official odes, consisted of Milton's smaller poems. A quarto edition appeared in 1790, with corrections and additions. The great object of these notes is to explain the allusions of Milton, to trace his imitations, and to illustrate his beauties.

Until he reached his sixty second year, he continued to enjoy vigorous and uninterrupted health. On being seized with the gout, he went to Bath, and flattered himself, on his return to college, that he was in a fair way of recovery. But the change that had taken place in his constitution was visible to his friends On Thursday, May 20, 1790, he passed the evening in the common room, and was for some time more cheerful than usual. Between ten and eleven o'clock he was struck with the palsy, and continued insensible till his death, which happened the next day at two o'clock. On the 27th, his remains were interred in the college chapel with the most distinguished academical honours.

Warton. The inscription upon the flat stone which is placed over his grave contains only an enumeration of his preferments.

Such was the general conduct and behaviour of Mr Warton as to render him truly amiable and respectable. By his friends he was beloved for his open and easy manners; and by the members of the university at large he was respected for his constant residence, strong attachment to Alma Mater, his studious pursuits, and high literary character In all parties where the company accorded with his inclination, his conversation was easy and gay, enlivened with humour, enriched with anecdote, and pointed with wit. Among his peculiarities it may be mentioned that he was fond of all military sights. He was averse to strangers, particularly to those of a literary turn; and yet he took a great pleasure in encouraging the efforts of rising genius, and assisting the studious with his advice; as many of the young men of his college, who shared his affability and honoured his talents, could testify. He was bred in the school of punsters; and made as many good ones as Barton and Leigh, the celebrated word-hunters of his day. Under the mask of indolence, no man was more busy; his mind was ever on the wing in search of some literary prey. Although, at the accustomed hours of Oxford study, he was often seen sauntering about, and conversing with any friend he chanced to meet; yet, when others were wasting their mornings in sleep, he was indulging his meditations in his favourite walks, and courting the Muses. His situation in Oxford was perfectly congenial with his disposition, whether he indulged his sallies of pleasantry in the common room, retired to his own study, or to the Bodleian library; sauntered on the banks of his favourite Cherwell, or surveyed, with the enthusiastic eye of taste, the ancient gateway of Magdalen College, and other specimens of Gothic architecture.

The following is a list of Mr Warton's works: 1. "Five Pastoral Eclogues," 4to, 1745. Reprinted in Pearch's Collection of Poems. 2. "The Pleasures of Melancholy," written in 1745; first printed in Dodsley's Collection, and afterwards in the Collection of Mr Warton's Poems 3. "Progress of Discontent," written in 1746. First printed in the "Student," a periodical paper. 4. "The Triumph of Isis, a Poem," 4to, 1750. 5. "Newmarket, a Satire," folio, 1751. 6. "Ode for Music," performed at the theatre in Oxford 1751. 7. "Observations on the Faerie Queen of Spenser," 8vo, 1754. 8. "Inscriptionum Metricarum Delectus," 4to, 1758. 9 "A Description of the City, College, and Cathedral, of Winchester," 8vo, no date. 10. "The Life of Sir Thomas Pope," in the 5th volume of the Biographia Britannica," republished in 1772. 11. "The Life and literary Remains of Ralph Bathurst, M. D. Dean of Wells, and President of Trinity College in Oxford," 1761. 12. "A Companion to the Guide, and a Guide to the Companion," 12mo, 1762. 13. "The Oxford Sausage," in which several Poems by Warton. 14. "Anthologiæ Græcæ a Constantino Cephalâ conditæ Libri tres," 2 tom. 1766. 15. "Theocritis Syracusii quæ supersunt, cum Scholiis Græcis," &c 2 tom. 4to, 1770. 16. "History of English Poetry, from the Close of the 11th to the Commencement of the 18th Century," 4to, Vol. I. 1774. Vol. II. 1778. Vol. III. 1781 17. "Poems," 8vo, 1777 18. "Specimen of a History of Oxfordshire," 1783. 19. "An Enquiry into the Authenticity of the Poems attributed to Thomas Rowley," 8vo, 1782. 20. Verses on Sir J. Reynolds's painted Window in New College Chapel. 4to." 1782. 21. "Poems on several Occasions, by John Milton, with Notes critical and explanatory," 8vo, 1785.

Washington.

WASHINGTON (George), whose name is likely to live as long as that of any modern, was born on the 11th of February 1732, in the parish of Washington, Virginia. He was descended from an ancient family in Cheshire, of which a branch had been established in Virginia about the middle of the 17th century. We are not acquainted with any remarkable circumstances of his education or his early youth; and we should not indeed expect any marks of that disorderly prematureness of talent, which is so often fallacious, in a character whose distinguishing praise was to be regular and natural. His classical instruction was probably small, such as the private tutor of a Virginian country gentleman could at that period have imparted; and if his opportunities of information had been more favourable, the time was too short to profit by them (A). Before he was twenty he was appointed a major in the colonial militia, and he had very early occasion to display those political and military talents, of which the exertions on a greater theatre have since made his name so famous throughout the world.

The plenipotentiaries who framed the treaty of Aix la Chapelle, by leaving the boundaries of the British and French territories in North America unfixed, had sown the seeds of a new war, at the moment when they concluded a peace. The limits of Canada and Louisiana, negligently described in vague language by the treaties of Utrecht and Aix la Chapelle, because the greater part of these vast countries was then an impenetrable wilderness, furnished a motive, or a pretext, for one of the most successful, but one of the most bloody and wasteful wars in which Great Britain had ever been engaged. See BRITAIN, *Encycl.*

In the disputes which arose between the French and English officers on this subject. Major Washington was employed by the governor of Virginia, in a negociation with the French governor of Fort du Quesne (now Pitsburgh); who threatened the English frontiers with a body of French and their Indian allies. He succeeded in averting the invasion; but hostilities becoming inevitable, he was in the next year appointed lieutenant colonel of a regiment raised by the colony for its own defence; to the command of which he soon after succeeded. The expedition of Braddock followed in the year

(A) Several accounts of the life of Washington have stated that he served as a midshipman on board a British frigate. This is a mistake. His elder brother, who died young, served in that capacity in Vernon's expedition against Carthagena; whence the family seat was called Mount Vernon. Washington himself never left the United States, except in one short voyage to a West India island, when he was very young.

year 1755; of which the fatal issue is too well known to require being described by us. Colonel Washington served in that expedition only as a volunteer; but such was the general confidence in his talents, that he may be said to have conducted the retreat. Several British officers are still alive who remember the calmness and intrepidity which he shewed in that difficult situation, and the voluntary obedience which was so cheerfully paid by the whole army to his superior mind. After having acted a distinguished part in a subsequent and more successful expedition to the Ohio, he was obliged by ill health, in the year 1758, to resign his military situation. The fixteen years which followed of the life of Washington supply few materials for the biographer. Having married Mrs Custis, a Virginian lady of amiable character and respectable connections, he settled at his beautiful seat of Mount Vernon, of which we have had so many descriptions; where, with the exception of such attendance as was required by his duties as a magistrate and a member of the assembly, his time was occupied by his domestic enjoyments, and the cultivation of his estate, in a manner well suited to the tranquillity of his pure and unambitious mind. At the end of this period he was called by the voice of his country from this state of calm and secure though unostentatious happiness.

For almost half a century symptoms of disaffection to the mother country had been so visible in the New England provinces, that so early as 1734 the celebrated Bishop Berkeley had predicted a total separation of North America from Great Britain. That prelate, when a private clergyman, had lived three years in Rhode Island, and was an attentive and sagacious observer of the manners and principles of the people, among whom he perceived the old leaven of their forefathers fermenting even then with great violence. The middle and southern provinces, however, were more loyal, and their influence, together with perpetual dread of the French before the peace of 1763, put off the separation to a more distant day than that at which, we have reason to believe, the Bishop expected it to take place. Virginia, the most loyal of all the colonies, had long been in the habit of calling itself, with a kind of proud pre-eminence, *his Majesty's ancient dominion*; and it was with some difficulty that the demagogues of New England could gain over that province when the time arrived for effecting their long meditated revolt. At last, however, they succeeded; and we find Mr Washington as a delegate from Virginia in the Congress which met at Philadelphia on the 26th of October 1774. (See America, n° 174. *Encycl.*) As no American united in so high a degree as he did, military experience with respectability of character, he was appointed to the command of the army which had assembled in the New England provinces, to hold in check the British army which was then encamped under General Gage at Boston.

At this period there is some reason to believe that neither Mr Washington nor his constituents entered heartily into the views of the New Englanders; but afraid lest the army of those rebellious fanatics, after shaking off the yoke of Great Britain, might give law to the continent, he took upon himself the command of that army in the month of July 1775 (n). To detail his conduct in the years which followed, would be to relate the history of the American war, which we have already related in the article America (*Encycl.*). Within a very short period after the declaration of independence, the affairs of America were in a condition so desperate, that perhaps nothing but the *peculiar* character of Washington's genius could have retrieved them. Activity was the policy of invaders. In the field of battle the superiority of a disciplined army is displayed. But delay was the wisdom of a country defended by undisciplined soldiers against an enemy who must be more exhausted by time than he could be weakened by defeat. It required the consummate prudence, the calm wisdom, the inflexible firmness, the moderate and well-balanced temper of Washington to embrace such a plan of policy, and to persevere in it: to resist the temptations of enterprize; to fix the confidence of his soldiers without the attraction of victory; to support the spirit of the army and the people amidst those slow and cautious plans of defensive warfare which are more dispiriting than defeat itself; to contain his own ambition and the impetuosity of his troops; to endure temporary obscurity for the salvation of his country, and for the attainment of solid and immortal glory; and to suffer even temporary reproach and obloquy, supported by the approbation of his own conscience and the applause of that small number of wise men, whose praise is an earnest of the admiration and gratitude of posterity. Victorious generals easily acquire the confidence of their army. Theirs, however, is a confidence in the *fortune* of their general. That of Washington's army was a confidence in his *wisdom*. Victory gives spirit to cowards, and even the agitations of defeat sometimes impart a courage of despair. Courage is inspired by success, and it may be stimulated to desperate exertion even by calamity; but it is generally palsied by inactivity.—A system of cautious defence is the severest trial of human fortitude; and by this test the firmness of Washington was tried. It must not, however, be concealed, that some of the British commanders gave him advantages, which he surely did not expect; for more than once, as it appears to us, they had it in their power to annihilate his army, merely by following up their victories. The issue of the contest is known.

Much has been said by the British and American democrates of the magnanimity of Washington during the ravages of a civil war, in which he acted so conspicuous a part; and we feel not ourselves inclined to refuse him the praise which he may have merited on this or on any other account. But granting that duty required him to execute as a spy the accomplished *André*, true magnanimity would have prevented him from insultingly erecting, in the view of that unfortunate officer, the gallows on which he was to be hung, several days

(n) That such were the motives of his conduct on this occasion, is rendered in the highest degree probable in the preface to *A View of the Causes and Consequences of the American Revolution, in thirteen Discourses, Preached in North America, between the years* 1763 and 1775; by Jonathan Boucher, A. M. and F. A. S. Vicar of Epsom in the County of Surrey.

days before his execution! When Earl Cornwallis was overpowered by numbers, and obliged at York-town to surrender to the united armies of America and France, a magnanimous conqueror would not have maliciously claimed, contrary to the usage of civilized war, the sword from the hands of that gallant nobleman. On these two occasions, and on some others, the conduct of Washington agreed so ill with his general character, that we are inclined to believe that he must have been influenced by the leaders of the French army Rochembeau and Fayette. One thing is certain, that he was so little pleased either with his own conduct on particular occasions, or with the general principle of the American revolution, that he never could be forced to talk on the subject. An Italian nobleman, who visited him after the peace, had often attempted, in vain, to turn the conversation to the events of the war. At length he thought he had found a favourable opportunity of effecting his purpose; they were riding together over the scene of an action where Washington's conduct had been the subject of no small animadversion. Count ——— said to him, "Your conduct, Sir, in this action has been criticised." Washington made no answer, but clapped spurs to his horse; after they had passed the field, he turned to the Italian and said, "Count ———, I observe that you wish me to speak of the war; it is a conversation which I always avoid. I rejoice at the establishment of the liberties of America. But the time of the struggle was a horrible period, in which the best men were compelled to do many things repugnant to their nature." This, we think, is the language of a good man not altogether satisfied with the part which he had been compelled to act, and who though he rejoiced at the establishment of the *liberties* of America, probably foresaw that she would reap no benefit from her favourite *independence*.

The conclusion of the American war permitted Washington to return to those domestic scenes, from which no views of ambition seem to have had the power to draw him. But he was not allowed long to enjoy this privacy. The supreme government of the United States, hastily thrown up, in a moment of turbulence and danger, as a temporary fortification against anarchy, proved utterly inadequate to the preservation of general tranquillity and permanent security. The confusions of civil war had given a taint to the morality of the people, which rendered the restraints of a just and vigorous government more indispensably necessary. Confiscation and paper money, the two greatest schools of rapacity and dishonesty in the world, had widely spread their poison among the Americans. One of their own writers tells us, that the whole system of paper money was a system of public and private frauds. In this state of things, which threatened the dissolution of morality and government, good men saw the necessity of concentrating and invigorating the supreme authority. Under the influence of this conviction, a convention of delegates was assembled at Philadelphia, which strengthened the bands of the Federal Union, and bestowed on Congress those powers which were necessary for the purposes of good government. Washington was the president of this convention, as he, in three years after, was elected president of the United States of America, under what was called "The New Constitution," tho' it ought to have been called a *reform* of the republican government, as that republican government itself was only a *reform* of the ancient colonial constitution under the British crown. None of these changes extended so far as an attempt to new-model the whole social and political system.

Events occurred during his chief magistracy which convulsed the whole political world, and which tried most severely his moderation and prudence. The French revolution took place; Washington, who had experienced the evils of one revolution, augured, from the beginning, no good from the daring speculations of inexperienced visionaries; and the progress of the revolution was not calculated to cure his distrust. When, in the year 1793, France, then groaning under the most intolerable and hideous tyranny, became engaged in war with almost all the governments of the civilized world, it is said to have been a matter of deliberation with the President of the United States, whether the republican envoy, or the agent of the French princes should be received in America as the diplomatic representative of France. But whatever might be his private feelings of repugnance and horror, his public conduct was influenced only by his public duties. As a virtuous man he must have abhorred the system of crimes which was established in France. But as the first magistrate of the American commonwealth, he was bound only to consider how far the interest and safety of the people whom he governed were affected by the conduct of France. He saw that it was wise and necessary for America to preserve a good understanding and a beneficial intercourse with that great country, in whatever manner she was governed, as long as she abstained from committing injury against the United States. Guided by this just and simple principle, uninfluenced by the abhorrence of crimes which he felt, and which others affected, he received Mr Genet, the minister of the French Republic. The history of the outrages which that minister committed, or instigated, or countenanced, against the American government, must be fresh in the memory of all our readers. The conduct of Washington was a model of firm and dignified moderation. Insults were offered to his authority in official papers, in anonymous libels, by incendiary declaimers, and by tumultuous meetings. The law of nations was trampled under foot. His confidential ministers were seduced to betray him, and the deluded populace were so inflamed by the arts of their enemies, that they broke out into insurrection. No vexation, however galling, could disturb the tranquillity of his mind, or make him deviate from the policy which his situation prescribed. With a more confirmed authority, and at the head of a longer established government, he might perhaps have thought greater vigour justifiable. But in his circumstances, he was sensible that the nerves of authority were not strong enough to bear being strained. Persuasion, always the most desirable instrument of government, was in his case the safest. Yet he never overpassed the line which separates concession from meanness. He reached the utmost limits of moderation, without being betrayed into pusillanimity. He preserved external and internal peace by a system of mildness, without any of those virtual confessions of weakness, which so much dishonour and enfeeble supreme authority. During the whole of that arduous struggle, his personal character gave that strength to a *new magistracy* which in other countries ...

ancient habits of obedience and respect. The authority of his virtue was more efficacious for the preservation of America than the legal powers of his office.

During this turbulent period, he was re-elected to the office of the Presidency of the United States, which he held from April 1789 till September 1796. Probably no magistrate of any commonwealth, ancient or modern, ever occupied a place so painful and perilous. Certainly no man was ever called upon so often to sacrifice his virtuous feelings (he had no other sacrifices to make) to his public duty. Two circumstances of this sort deserve to be particularly noticed. In the spring of 1794, he sent an ambassador to Paris with credentials, addressed to his "Dear friends the citizens composing the Committee of Public Safety of the French Republic," whom he prays God "to take under his holy protection." Fortunately the American ambassador was spared the humiliation of presenting his credentials to these bloody tyrants. Their power was subverted, and a few of them had suffered the punishment of their crimes, which no punishment could expiate, before his arrival at Paris. Readily as we admit the purity of the motives which induced him to send this embassy to Paris, we cannot possibly approve of his conduct in deviating so far from the usual diplomatic style, as to call Robespierre his friend: but he was beset by an absurd, though formidable, faction at home.

He had another struggle of feeling and duty to encounter, when he was compelled to suppress the insurrection in the western counties of Pennsylvania by force of arms. But here he had a consolation. The exercise of mercy consoled his mind for the necessity of having recourse to arms. Never was there a revolt quelled with so little blood. Scarcely ever was the basest dastard so tender of his own life, as this virtuous man was of the lives of his follow citizens. The value of his clemency is enhanced by recollecting that he was neither without provocations to severity, nor without pretexts for it. His character and his office had been reviled in a manner almost unexampled among civilized nations. His authority had been insulted.—His safety had been threatened. Of his personal and political enemies some might, perhaps, have been suspected of having instigated the insurrection; a greater number were thought to wish well to it; and very few shewed much zeal to suppress it. *Is habitus animorum fuit, ut pessimum facinus auderent pauci, plures vellent, omnes paterentur.* But neither resentment, nor fear, nor even policy itself, could extinguish the humanity of Washington. This seems to have been the only sacrifice which he was incapable of making to the interest of his country.

Throughout the whole course of his second Presidency, the danger of America was great and imminent almost beyond example. The spirit of change, indeed, at that period, shook all nations. But in other countries it had to encounter ancient and solidly established power; it had to tear up by the roots long habits of attachment in some nations for their government; of awe in others; of acquiescence and submission in all.—But in America the government was new and weak. The people had scarce time to recover from the ideas and feelings of a recent civil war. In other countries the volcanic force must be of power to blow up the mountains, and to convulse the continents that held it down, before it could escape from the deep caverns in which it was imprisoned:—in America it was covered only by the ashes of a late convulsion, or at most by a little thin soil, the produce of a few years quiet.

The government of America had none of those salutary prejudices to employ, which in every other country were used with success to open the eyes of the people to the enormities of the French revolution. They had, on the contrary, to contend with the prejudices of their people in the most moderate precautions against internal confusion, in the most measured and guarded resistance to the unparalleled insults and enormous encroachments of France. Without zealous support from the people, the American government was impotent. It required a considerable time, and it cost an arduous and dubious struggle, to direct the popular spirit against a sister republic, established among a people to whose aid the Americans ascribed the establishment of their independence. It is probable, indeed, that no policy could have produced this effect, unless it had been powerfully aided by the crimes of the French government, which have proved the strongest allies of all established governments; which have produced such a general disposition to submit to any *known* tyranny, rather than rush into all the unknown and undefinable evils of civil confusion, with the horrible train of new and monstrous *tyrannies* of which it is usually the forerunner. But of these circumstances Washington availed himself with uncommon address. He employed the horror excited by the atrocities of the French revolution for the most honest and praise-worthy purposes; to preserve the internal quiet of his country; to assert the dignity, and to maintain the rights, of the commonwealth which he governed, against foreign enemies. He avoided war without incurring the imputation of pusillanimity. He cherished the detestation of Americans for anarchy, without weakening the spirit of liberty; and he maintained, and even consolidated, the authority of government, without abridging the privileges of the people.

The resignation of Washington in 1796 was certainly a measure of prudence, and we doubt not of patriotism; but the conduct of his successor has been such as to give the Americans reason to regret that the reins of government were thrown up by the only hand, perhaps, that was fit to guide them during so unsettled a state of public affairs. When he retired, he published a valedictory address to his countrymen, as he had before done when he quitted the command of the army in 1783. In these compositions, the whole heart and soul of Washington are laid open. Other state papers have, doubtless, shewn more spirit and dignity, more eloquence, greater force of genius, and a more enlarged comprehension of mind; but none ever displayed more simplicity and ingenuousness, more moderation and sobriety, more good sense, more prudence, more honesty, more earnest affection for his country and for mankind, more profound reverence for virtue and religion; more ardent wishes for the happiness of his fellow-creatures, and more just and rational views of the means which alone can effectually promote that happiness.

From his resignation till the month of July 1798, he lived in retirement at Mount Vernon. At this latter period, it became necessary for the United States to arm. They had endured with a patience, of which there is no example in the history of states, all the contumely

Washington, Watchwork.

tunely and wrong which successive administrations in France had heaped upon them. Their ships were everywhere captured, their ministers were detained in a fort of imprisonment at Paris; while incendiaries, clothed in the sacred character of ambassadors, scattered over their peaceful provinces the fire brands of sedition and civil war. An offer was made to terminate this long course of injustice, for a bribe to the French ministers. This offer was made by persons who *appeared* to be in the confidence of M. Talleyrand, who *professed* to act by his authority; who have been since, indeed, disavowed by him; but who never will be believed not to have been his agents, till he convict them of imposture by legal evidence, and procure them to be punished for so abominable a fraud.

The United States resolved to arm by land and sea. The command of the army was bestowed on General Washington; which he accepted, because he was convinced that "every thing we hold dear and sacred was seriously threatened*;" though he had flattered himself "that he had quitted for ever the boundless field of public action, incessant trouble and high responsibility, in which he had long acted so conspicuous a part." In this office he continued during the short period of his life which still remained.—On Thursday the 12th December 1799, he was seized with an inflammation in his throat, which became considerably worse the next day; and of which, notwithstanding the efforts of his physicians, he died on Saturday the 14th of December 1799, in the 68th year of his age, and in the 23d year of the independence of the United States, of which he may be considered as the founder. The same calmness, simplicity, and regularity, which had uniformly marked his demeanor, did not forsake him in his dying moments. He saw the approaches of death without fear: —he met them without parade.—Even the perfectly well-ordered state of the most minute particulars of his private business, bore the stamp of that constant authority of prudence and practical reason over his actions, which was a distinguishing feature of his character. He died with those sentiments of piety which had given vigour and consistency to his virtue, and adorned every part of his illustrious life.

* See his *Letter of Acceptance*.

WATCHWORK. Our intention in this article does not extend to the manual practice of this art, nor even to all the parts of the machine We mean to consider the most important and difficult part of the construction, namely, the method of applying the maintaining power of the wheels to the regulator of the motion, so as not to hurt its power of regulation. Our observations would have come with more propriety under the title SCAPEMENT, that being the name given by our artists to this part of the construction. Indeed they were intended for that article, which had been unaccountably omitted in the body of the Dictionary under the words CLOCK and WATCH. But the bad health and occupations of the person who had engaged to write the article, have obliged us to defer it to the last opportunity which the alphabetical arrangement affords us; and, even now, the same causes unfortunately prevent the author from treating the subject in the manner he intended, and which it well deserves. But we trust that, from the account which is here given, the reader, who is conversant in mathematical philosophy, will perceive the justness of the conclusions, and that an intelligent artist will have no hesitation in acceding to the propriety of the maxims of construction deduced from them.

The regulator of a clock or watch is a pendulum or a balance. Without this check to the motion of the wheels, impelled by a weight or a spring, the machine would run down with a motion rapidly accelerating, till friction and the resistance of the air induced a sort of uniformity, as they do in a kitchen jack. But if a pendulum be so put in the way of this motion, that only one tooth of a wheel can pass it at each vibration, the revolution of the wheels will depend on the vibration of the pendulum. This has long been observed to have a certain constancy, insomuch that the astronomers of the East employed pendulums in measuring the times of their observations, patiently counting their vibrations during the phases of an eclipse or the transits of the stars, and renewing them by a little push with the finger when they became too small Gassendi, Riccioli, and others, in more recent times, followed this example. The celebrated physician Sanctorius is the first person who is mentioned as having applied them as regulators of clock movements. Machines, however, called *clocks*, with a train of toothed wheels, leading round an index of hours, had been contrived long before. The earliest of which we have any account is that of Richard of Wallingford, Abbot of St Alban's, in 1326 (A). It appears to have been regulated by a fly like a kitchen jack*. Not long after this Giacomo Dondi made one at Padua, which had a *motus succussorius*, a hobbling or trotting motion; from which expression it seems probable that it was regulated by some alternate movement. We cannot think that this was a pendulum, because, once it was introduced, it never could have been supplanted by a balance. The alternate motion of a pendulum, and its seeming uniformity, are among the most familiar observations of common life; and it is surprising that they were not more early thought of for regulating time measurers. The alternate motions of the old balance is one of the most far-fetched means that can be imagined, and might pass for the invention of a very reflecting mind, while a pendulum only requires to be drawn aside from the plumb-line, to make it vibrate with regularity. The balance must be put in motion by the clock, and that motion must be stopped, and the contrary motion induced; and we must know that the same force and the same checks will produce uniform oscillations. All this must be previously known before we can think of it as a regulator; yet so it is that clocks, regulated by a balance, were long used, and very common through Europe, before Galileo proposed the pendulum, about the year 1600. Pendulum clocks then came into general use, and were found to be greatly preferable to balance clocks as accurate measurers of time. Mathematicians saw that their vibrations had some regular-

* [illegible]

(A) Professor Beckmann, in the first volume of his *History of Inventions*, expresses a belief that clocks of this kind were used in some monasteries so early as the 11th century, and that they were derived to the monks from the Saracens. His authorities, however, are discordant, and seem not completely satisfactory even to himself.

Watch-work.

gular dependence on uniform gravity, and in their writings we meet with many attempts to determine the time and demonstrate the isochronism of the vibrations. It is amusing to read these attempts. We wonder at the awkwardness and insufficiency of the explanation given of the motions of pendulums, even by men of acknowledged eminence. Mersennus carried on a most useful correspondence with all the mathematicians of Europe, and was the means of making them acquainted with each other; nay, he was himself well conversant in the science; yet one cannot but smile at his reasonings on this subject. Standing on the shoulders of our predecessors, we look around us, in great satisfaction with our own powers of observation, not thinking how we are raised up, or that we are trading with the stock left us by the diligent and sagacious philosophers of the 17th century (B). Riccioli, Gassendus, and Galileo, made similar attempts to explain the motion of pendulums; but without success. This honour was reserved for Mr Huyghens, the most elegant of modern geometers. He had succeeded in 1656 or 1657 in adapting the machinery of a clock to the maintaining of the vibrations of a pendulum. Charmed with the accuracy of its performance, he began to investigate with scrupulous attention the theory of its motion. By the most ingenious and elegant application of geometry to mechanical problems, he demonstrated that the wider vibrations of a pendulum employed more time than the narrower, and that the time of a semicircular vibration is to that of a very small one nearly as 34 to 29; and, aided by a new department of geometrical science invented by himself, namely, the evolution of curves, he shewed how to make a pendulum swing in a cycloid, and that its vibrations in this curve are all performed in equal times, whatever be their extent.

But before this time, Dr Hooke, the most ingenious and inventive mechanician of his age, had discovered the great accuracy of pendulum clocks, having found that the manner in which they had been employed had obscured their real merit. They had been made to vibrate in very large arches, the only motion that could be given them by the contrivances then known; and in 1656 he invented another method, and made a clock which moved with astonishing regularity. Using a heavy pendulum, and making it swing in very small arches, the clocks so constructed were found to excel Mr Huyghens's cycloidal pendulums; and those who were unfriendly to Huyghens had a sort of triumph on the occasion. But this was the result of ignorance. Mr Huyghens had shewn, that the error of $\frac{1}{100}$ of an inch, in the formation of the parts which produced the cycloidal motion, caused a greater irregularity of vibration than a circular vibration could do, although it should extend five or six degrees on each side of the perpendicular. It has been found that the unavoidable inaccuracies, even of the best artists, in the cycloidal construction, make the performance much inferior to that of a common pendulum vibrating in arches which do not exceed three or four degrees from the perpendicular. Such clocks alone are now made, and they exceed all expectation.

We have said that a pendulum needed only to be removed from the perpendicular, and then let go, in order to vibrate and measure time. Hence it might seem, that nothing is wanted but a machinery so connected with the pendulum as to keep a register, as it were, of the vibration. It could not be difficult to contrive a method of doing this; but more is wanted. The air must be displaced by the pendulum. This requires some force, and must therefore employ some part of the momentum of the pendulum. The pivot on which it swings occasions friction—the thread, or thin piece of metal by which it is hung, in order to avoid this friction, occasions some expenditure of force by its want of perfect flexibility or elasticity. These, and other causes, make the vibrations grow more and more narrow by degrees, till at last the pendulum is brought to rest. We must therefore have a contrivance in the wheelwork which will restore to the pendulum the small portion of force which it loses in every vibration. The action of the wheels therefore may be called a *maintaining power*, because it keeps up the vibrations.

But we now see that this may affect the regularity of vibration. If it be supposed that the action of gravity renders all the vibrations isochronous, we must grant that the additional impulsion by the wheels will destroy that isochronism, unless it be so applied that the sum total of this impulsion and the force of gravity may vary so with the situation of the pendulum, as still to give a series of forces, or a law of variation, perfectly similar to that of gravity. This cannot be effected, unless we know both the law which regulates the action of gravity, producing isochronism of vibration, and the intensity of the force to be derived from the wheels in every situation of the pendulum.

The necessary requisite for the isochronous motion of the pendulum is, that the force which urges it toward the perpendicular, be proportional to its distance from it (see DYNAMICS, n° 103. Cor. 7. *Suppl.*); and therefore, since pendulums swinging in small circular arches are sensibly isochronous, we must infer that such is the law by which the accelerating action of gravity on them is really accommodated to every situation in those arches.

It will greatly conduce to the better understanding of the effect of the maintaining power, if the reader keep in continual view the chief circumstances of a motion of this kind. Therefore let AC*a* (fig. 1.) represent the arch passed over by the pendulum, stretched out into a straight line. Let C be its middle point, when the pendulum hangs perpendicular, and A and *a* be the extremities of the oscillation. Let AD be drawn perpendicular to AC, to represent the accelerating action of gravity on the pendulum when it is at A. Draw the straight line DC*d*, and *ad*, perpendicular to A*a*. About C, as a centre, describe the semicircle AFH*a*. Through

Plate XLVIII.

(B) We are provoked to make this observation, by observing at this moment, in a literary journal, a pert and petulant upstart speaking of Newton's optical discoveries in terms of ridicule and abuse, employing these very discoveries to diminish his authority. Is it not thus that Christianity is now slighted by those who enjoy the fruits of the pure morality which it introduced?

Through any points B, K, *k*, *b*, &c. of A *a*, draw the perpendiculars BFE, KLM, &c. cutting both the straight line and the semicircle. Then,

1. The actions of gravity on the pendulum, when in the situations B, K, &c. by which it is urged toward C, are proportional to, and may be represented by, the ordinates BE, KL, *be*, *kl*, &c. to the straight line DC *d*.

2. The velocities acquired at B, K, &c. by the acceleration along AB, AK, &c. are proportional to the ordinates BF, KM, &c. to the semicircle AH *a*; and, therefore, the velocity with which the pendulum passes through the middle point C, is to its velocity in any other point B, as CH to BF.

3. The times of describing the parts AB, BK, KC, &c. of the whole arch of oscillation, are proportional to, and may be represented by, the arches AF, FM, MH, &c. of the semicircle.

4. If one pendulum describe the arch represented by AC *a*, and another describe the arch KC *k*, they will describe them in equal times, and their maximum velocities (viz. their velocities in the middle point), are proportional to AC and KC; that is, the velocities in the middle point are proportional to the width of the oscillations.

The same proportions are true with respect to the motions outwards from C. That is, when the pendulum describes CA, with the initial velocity CH, its velocity at K is reduced to KM by the retarding action of gravity. It is reduced to BF at B, and to nothing at A; and the times of describing CK, KB, BA, CA, are as HM, HF, HA. Another pendulum setting out from C, with the initial velocity CO, reaches only to K, CK being = CO. Also the times are equal.—If we consider the whole oscillation as performed in the direction A *a*, the forces AD, BE, KL accelerate the pendulum, and the similar forces *a d*, *b e*, *k l*, on the other side, retard it. The contrary happens in the next oscillation *a*CA.

5. The areas DABE, DAKL, &c. are proportional to the squares of the velocities acquired by moving along AB, AK, &c. or to the diminution of the squares of the velocities sustained by moving outwards along BA or KA, &c.

The consideration of this figure will enable the reader (even though not a mathematician) to form some notion of the effect of any proposed application of a maintaining power by means of wheelwork: For, knowing the weight of the pendulum, we know the accelerating action of that weight in any particular situation A of the pendulum. We also know what addition or subtraction we produce on the pendulum in that situation by the wheel-work. Suppose it is an addition of pressure equal to a certain number of grains. We can make AD to D*δ* as the first to the last; and then A*δ* will be the whole force urging the pendulum toward C. Doing the same for every point of AC, we obtain a line *δ ε λ c*, which is a new scale of forces, and the space DC*δ*, comprehended between the two scales CD and C*δ*, will express the addition made to the square of the velocity in passing along AC by the joint action of gravity and the maintaining power. Also, by drawing a line *x π* perpendicular to AC, making the space C*π x* equal to CAD, the point *π* will be the limit of the oscillation outward from C, where the initial velocity HC is extinguished. If the line *x π* cut the same circle in *ς*, one-half the arch *ς* A will nearly express the contraction made in the time of the outward oscillation by the maintaining power. An accurate determination of this last circumstance is operose, and even difficult; but this solution is not far from the truth, and will greatly assist our judgment of the effect of any proposal, even though *x π* be drawn only by the judgement of the eye, making the area left out as nearly equal to the area taken in as we can estimate by inspection. This is said from experience.

Since the motion of a pendulum or balance is alternate, while the pressure of the wheels is constantly in one direction, it is plain that some art must be used to accommodate the one to the other. When a tooth of the wheel has given the balance a motion in one direction, it must quit it, that it may get an impulsion in the opposite direction. The balance or pendulum thus escaping from the tooth of the wheel, or the tooth escaping from the balance, has given to the general contrivance the name of SCAPEMENT among our artists, from the French word *echappement*. We proceed, therefore, to consider this subject more particularly, first considering the scapements which are peculiarly suited to the small vibrations of pendulums, and then those which must produce much wider vibrations in balances. This, with some other circumstances, render the scapements for pendulums and balances very different.

I. *Of the Action of a Wheel and Pallet.*

THE scapement which has been in use for clocks and watches ever since their first appearance in Europe, is extremely simple, and its mode of operation is too obvious to need much explanation. In fig. 2. XY represents a horizontal axis, to which the pendulum P is attached by a slender rod, or otherwise. This axis has two leaves C and D attached to it, one near each end, and not in the same plane, but so that when the pendulum hangs perpendicularly, and at rest, the piece C spreads a few degrees to the right hand, and D as much to the left. They commonly make an angle of 70, 80, or 90 degrees. These two pieces are called PALLETS. AFB represents a wheel, turning round on a perpendicular axis EO, in the order of the letters AFEB. The teeth of this wheel are cut into the form of the teeth of a saw, leaning forward, in the direction of the motion of the rim. As they somewhat resemble the points of an old fashioned royal diadem, this wheel has got the name of the CROWN WHEEL. In watches it is often called the *balance wheel*. The number of teeth is generally odd; so that when one of them B is pressing on a pallet D, the opposite pallet C is in the space between two teeth A and I. The figure represents the pendulum at the extremity of its excursion to the right hand, the tooth A having just escaped from the pallet C, and the tooth B having just dropped on the pallet D. It is plain, that as the pendulum now moves over to the left, in the arch PG, the tooth B *continues* to press on the pallet D, and thus accelerates the pendulum, both during its descent along the arch PH, and its ascent along the arch HG. It is no less evident, that when the pallet D by turning round the axis XY, raises its point above the plane of the wheel, the tooth B escapes from it, and I drops on the pallet C, which is now nearly perpendicular. I presses C to the right, and

and accelerates the motion of the pendulum along the arch GP. Nothing can be more obvious than this action of the wheel in maintaining the vibrations of the pendulum. We can easily perceive, also, that when the pendulum is hanging perpendicularly in the line XH, the tooth B, by pressing on the pallet D, will force the pendulum a little way to the left of the perpendicular, and will force it so much the farther as the pendulum is lighter; and, if it be sufficiently light, it will be forced so far from the perpendicular that the tooth B will escape, and then I will catch on C, and force the pendulum back to P, where the whole operation will be repeated. The same effect will be produced in a more remarkable degree, if the rod of the pendulum be continued through the axis XY, and a ball Q put on the other end to balance P. And, indeed, this is the contrivance which was first applied to clocks all over Europe, before the application of the pendulum. They were balance clocks. The force of the wheel was of a certain magnitude, and therefore able, during its action on a pallet, to communicate a certain quantity of motion and velocity to the balls of the balance. When the tooth B escapes from the pallet D. the balls are then moving with a certain velocity and momentum. In this condition, the balance is checked by the tooth I catching on the pallet C. But it is not instantly stopped. It continues its motion a little to the left, and the pallet C forces the tooth I a little backward. But it *cannot* force it so far as to escape over the top of the tooth I; because all the momentum of the balance was generated by the force of the tooth B; and the tooth I is equally powerful. Besides, when I catches on C, and C continues its motion to the left, its lower point applies to the face of the tooth I, which now acts on the balance by a long and powerful lever, and soon stops its farther motion in that direction, and now, continuing to press on C, it urges the balance in the opposite direction.

Thus we see that in a scapement of this kind, the motion of the wheel must be very hobbling and unequal, making a great step forward, and a short step backward, at every beat. This has occasioned the contrivance to get the name of the RECOILING SCAPEMENT, the recoiling pallets. This hobbling motion is very observable in the wheel of an alarm.

Thus have we obtained two principles of regulation. The first and most obvious, as well as the most perfect, is the natural isochronous vibration of a pendulum. The only use of the wheelwork here, besides registering the vibrations, is to give a gentle impulsion to the pendulum, by means of the pallet, in order to compensate friction, &c. and thus maintain the vibrations in their primitive magnitude. But there is no such native motion in a balance, to which the motion of the wheels must accommodate itself. The wheels, urged by a determined pressure, and acting through a determined space (the face of the pallet), must generate a certain determined velocity in the balance; and therefore the time of the oscillation is also determined, both during the progressive and the retrograde motion of the wheel. The actions being similar, and through equal spaces, in every oscillation, they must employ the same time. Therefore a balance, moved in this manner, must be isochronous, and a regulator for a time-keeper.

By thus employing a balance, the horizontal position of the axis XY is unnecessary. Accordingly, the old clocks had this axis perpendicular, by which means the whole weight of the balance rested on the point of the pivot Y or X, according as the balance PQ was placed above or below. By making the supporting pivot of hard steel, and very sharp, friction was greatly diminished. Nay, it was entirely removed from this part of the machine by suspending the balance by a thread at the end X instead of allowing it to rest on the point of the pivot Y.

As the balance regulator of the motion admits of every position of the machine, those clocks were made in an infinite variety of fanciful forms, especially in Germany, a country famous for mechanical contrivances. They were made of all sizes, from that of a great steeple clock, to that of an ornament for a lady's toilet. The substitution of a spring in place of a weight, as a first mover of the wheel-work, was a most ingenious thought. It was very gradual. We have seen, in the Emperor's museum at Brussels, an old (perhaps the first) spring clock, the spring of which was an old sword blade, from the point of which a catgut was wound round the barrel of the first wheel. Some ingenious German substituted the spiral spring, which both took less room, and produced more revolutions of the first wheel.

When clocks had been reduced to such small sizes, the wish to make them portable was very natural; and the means of accomplishing this were obvious, namely, a farther reduction of their size. This was accomplished very early; and thus we obtained pocket watches, moved by a spiral spring, and regulated by a balance with the recoiling scapement, which is still in use for common watches. The hobbling motion of the crown wheel is very easily seen in all of them.

It is very uncertain who first substituted a pendulum in place of the balance (CLOCK, *Encycl.*) Huyghens, as we have already observed, was the first who investigated the motions of pendulums with success, and his book *De Horologio Oscillatorio* may be considered as the elements of refined mechanics, and the source of all the improvements that have been made in the construction of scapements. But it is certain that Dr Hooke had employed a pendulum for the regulation of a clock many years before the publication of the abovementioned treatise, and he claims the merit of the invention of the *only proper* method of employing it. We imagine therefore that Dr Hooke's invention was nothing more than a scapement for a pendulum making small vibrations, without making use of the opposite motions of the two sides of the crown wheel. Dr Hooke had contrived some scapement more proper for pendulums than the recoiling pallets, because certainly those might be employed, and are actually employed as a scapement for pendulum clocks to this day, although they are indeed very ill adapted to the purpose. He had not only remarked the great superiority of such pendulum clocks as were made before Huyghens's publication of the cycloidal pendulum over the balance clocks, but had also seen their defects, arising from the light pendulums and wide arches of vibration, and invented a scapement of the nature of those now employed. The pendulum clock which he made in 1658 for Dr Wilkins afterwards Bishop of Chester, is mentioned by the inventor as peculiarly suited to the moderate swing of a pendulum; and he opposes this circumstance to a general

practice

practice of wide vibrations and trifling pendulums. The French are not in the practice of ascribing to us any thing that they can claim as their own; yet Lepaute says that the *Echappement à l'Ancre* came from England about the year 1665. It is also admitted by him that clock-making flourished in England at that time, and that the French artists went to London to improve in it. Putting these and other circumstances together, we think it highly probable that we are indebted to Dr Hooke for the scapement now in use. The principle of this is altogether different from the simple pallets and direct impulse already described; and is so far from being obvious, that the manner of action has been misunderstood, even by men of science, and writers of systems of mechanics.

In this scapement we employ those teeth of the wheel which are moving in one direction; whereas in the former scapement, opposite teeth were employed moving in contrary directions. Yet even here we must communicate an alternate motion to the axis of the pallets. The contrivance, in general, was as follows: On the axis A (See fig. 3) of the pendulum or balance is fixed a piece of metal BAC, called the CRUTCH by our artists, and the ANCHOR by the French. It terminates in two faces B *b* C *c* of tempered steel, or of some hard stone. These are called the PALLETS, and it is on them that the teeth of the wheel act. The faces B *b* C *c* are set in such positions that the teeth push them out of the way. Thus B pushes the pallet to the left, and C pushes its pallet to the right. Both push their pallets sidewise outward from the centre of the wheel. The pallet B is usually called the *leading*, and C the *driving* pallet by the artists, although it appears to us that these names should be reversed, because B *drives* the pallet out of the way, and C *pulls* or leads it out of the way. They might be called the *first* and *second* pallet, in the order in which they are acted on by the wheel. We shall use either denomination. The figure is accommodated to the inactive or resting position of the pendulum. Suppose the pendulum drawn aside to the right at Q, and then let go. It is plain that the tooth B, pressing on the face of the pallet β B *b* all the way from β to *b*, thrusts it aside outwards, and thus, by the connection of the crutch with the pendulum rod, aids the pendulum's motion along the arch QPR. When the pendulum reaches R, the point of the tooth B has reached the angle *b* of the pallet, and escapes from it. The wheel pressing forward, another tooth C drops on the pallet face C *c*, and, by pressing this pallet outward, evidently aids the pendulum in its motion from R to P. The tooth C escapes from this pallet at the angle *c*, and now a tooth B′ drops on the first pallet, and again aids the pendulum; and this operation is repeated continually.

The mechanism of this communication of motion is thus explained by several writers of elements. The tooth B (fig. 2.) is urged forward in the direction BD, perpendicular to the radius MB of the SWING WHEEL. It therefore presses on the pallet, which is moveable only in the direction BE, perpendicular to BA the radius of the pallet. Therefore the force BD must be resolved into two, *viz.* BE, in the direction in which alone the pallet can move, and ED, or BF, perpendicular to that direction. The last of these only presses the pallet and crutch against the pivot hole A. BE is the only useful force, or the force communicated to the pallet, enabling it to maintain the pendulum's motion, by restoring the momentum lost by friction and other causes.

But this is a very erroneous account of the *modus operandi*, as may be seen at once, by supposing the radius of the pallets to be a tangent to the wheel. This is a position most frequently given to them, and is the very position in fig. 3. In this case MB is perpendicular to BA, and therefore BD will coincide with BA, and there will be no such force as BE to move the pendulum. It is a truth, deducible from what we know of the mechanical constitution of solid bodies, and confirmed by numberless observations, that when two solid bodies press on each other, either in impulsion or in dead pressure, the direction in which the mutual pressure is excited is always perpendicular to the touching surfaces, whatever has been the direction of the impelling body (See IMPULSION, *Suppl.* n° 66. MACHINERY, *Suppl.* n° 35. and several other parts of this Work) Moreover this pressure is mutual, equal, and opposite. Whatever be the shapes of the faces of the tooth and pallet, we can draw a plane BN, which is the common tangent to both surfaces, and a line HBI through the point of contact perpendicular to BN. It is farther demonstrated in the article MACHINERY, *Suppl.* n° 35. &c. that the action of the wheel on the pendulum is the same as if the whole crutch were annihilated, and in its stead there were two rigid lines AH, MI, from the centres of the crutch and wheel, perpendicular to HI, and connected by a third rigid line or rod HI, touching the two in H and I.

For if a weight V be hung at *v*, the extremity of the horizontal radius M *v* of the wheel, it will act on the lever *v* MI, pressing its point I upwards in the direction IH perpendicular to MI; the upper end of this rod IH will, in like manner, press the extremity H of the rod HA, and this will urge the pendulum from P toward R. To withstand this, the pendulum rod AP may be withheld by a weight *z*, hanging by a thread on the extremity of the horizontal lever A *z*, equal to M *v*, and connected with the crutch and pendulum. The weights V and *z* may be so proportioned to each other that, by acting perpendicularly on the crooked levers *v* MI, and *z* AH, the pressures at H and I shall be equal, and just balance each other by the intervention of the rod HI. When this is the case, we have put things into the same mechanical state, in respect of mutual action, as is effected by the crutch, pallets, and wheel, which in like manner, produce equal pressures at B the point of contact, in the direction BH and BI. The weight V may be such as produces the very same effect at B that is produced by the previous train of wheel-work. The weight *z* therefore must be just equal to the force produced by the wheel-work on the point *z* of the pendulum rod, because by acting in the opposite direction it just balances it. Let us see therefore what force is communicated to the pendulum by the wheels.

Let *x* be the upward pressure excited at I, and *y* the equal opposite pressure excited at H. Then, by the property of the lever, we have $\text{MI} : \text{M}v = \text{V} : x$, and $x \times \text{MI} = \text{V} \times \text{M}v$. In like manner $y \times \text{AH} = \text{Z} \times \text{A}z$. Therefore, because $x = y$, and $\text{A}z = \text{M}v$, we have $\text{V} : \text{Z} = \text{MI} : \text{AH}$. That is, the force exerted

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ed by the tooth of the wheel in the direction of its motion is to the force impressed on the pendulum rod at a distance equal to the radius of the wheel as MI to AH. The force impressed on the ball of the pendulum is less than this in the proportion of AP to A z, or M v.

Cor. 1. If the perpendiculars MN, AV, be drawn on the tangent plane, the forces at B and z will be as BN to BO. For these lines are respectively equal to MI and AH.

Cor. 2. If HI meet the line of the centres AC in S, the forces will be as SM to SA; that is, V : Z = SM : SA.

Cor. 3. If the face β B b of the pallet be the evolutrix of a circle described with the radius AH, and the face of the tooth be the evolutrix of a circle described with the radius MI, the force impressed on the pendulum by the wheels will be constant during the whole vibration (MACHINERY, n° 36) But these are not the only forms which produce this constancy. The forms of teeth described by different authors, such as De la Hire. Camus, &c. for producing a constant force in trains of wheel-work, will have the same effect here. It is also easy to see that the force impressed on the pendulum may be varied according to any law, by making these faces of a proper form. Therefore the face, from B outwards, may be so formed that the force communicated to the pendulum by the wheels, during its descent from Q to P, may be in one constant proportion to the acceleration of gravity, and then the sum of the forces will be such as produce isochronous vibrations. If the inner part B b of the face be formed on the same principle, the difference of the forces will have the same law of variation. If the face β b be the evolutrix of a circle, and the tooth B terminate in a point gently rounded, or quite angular, the force on the pendulum will continually increase as the tooth slides from β to b. For the line AH continues of the same magnitude, and MI diminishes. The contrary will happen, if the pallet be a point, either sharp or rounded, and if the face of the tooth be the evolutrix now mentioned; for MI will remain the same, while AH diminishes. If the tooth be pointed, and β b be a straight line, the force communicated to the pendulum will diminish, while the tooth slides from β to b. For in this case AH diminishes and MI increases.

Cor 4. In general, the force on the pendulum is greater as the angle MB b increases, and as AB b diminishes.

Cor. 5. The angular velocity of the wheel is to that of the pendulum, in any part of its vibration, as AH to MI This is evident, because the rod IH moving (in the moment under consideration) in its own direction, the points H and I move through equal spaces, and therefore the angles at A and M must be inversely as the radii

All that has now been said of the first pallet AB may be applied to the second pallet AC

If the perpendiculars C s be drawn to the touching plane o C n, cutting AM in s, we shall have V : z = s M : s A, as in Cor. 2. And if the perpendiculars M i, A h, be drawn on C r, we have V : Z = M i : A h, as in the general theorem. The only difference between the action on the two pallets is, that if the faces of both are plain, the force on the pendulum increases during the whole of the action on the pallet C, whereas it diminishes during the progress of the tooth along the other pallet.

The reader will doubtless remark that each tooth of the wheel acts on both pallets in succession; and that, during its action on either of them, the pendulum makes one vibration Therefore the number of vibrations during one turn of the wheel is double the number of the teeth: consequently, while the tooth slides along one of the pallets, it advances half the space between two successive teeth; and when it escapes from the pallet, the other tooth *may* be just in contact with the other pallet. We say it *may* be so; in which case there will be no dropping of the teeth from pallet to pallet. This, however, requires very nice workmanship. and that every tooth be at precisely the same distance from its neighbour. Should the tooth which is just going to apply to a pallet chance to be a little too far advanced on the wheel, it would touch the pallet before the other had escaped. Thus, suppose that before B escapes from the point b of the pallet, the tooth C is in contact with the pallet CG, B cannot escape. Therefore when the pendulum returns from R towards Q, the pallet β b, returning along with it, will push back the tooth B of the wheel. It does this in opposition to the force of the wheel. Therefore, whatever motion the wheel had communicated to the pendulum, during its swing from P to Q, will now be taken from it again. The pendulum will not reach Q, because it had been aided in its motion from Q and had proceeded further than it would have done without this help. Its motion toward Q is further diminished by the friction of the pallet. Therefore it will now return again from some nearer point q, and will not go so far as in the last vibration, but will return through a still shorter arch: And this will be still more contracted in the next vibration, &c. &c. Thus it appears that if a tooth chances to touch the pallet before the escape of the other, the wheel will advance no farther, and soon after the pendulum will be brought to rest.

For such reasons it is necessary to allow one tooth to escape *a little before* the other reaches the pallet on which it is to act, and to allow a small drop of the teeth from pallet to pallet. But it is accounted bad workmanship to let the drop be considerable, and *close scapement* is accounted a mark of care and of good workmanship. It is evidently an advantage, because it gives a longer time of action on each pallet. This freeing the scapement cannot be accomplished by filing something from the face of the tooth; because this being done to all, the distance between them is diminished rather than augmented. The pallets must be first scaped as close as possible. This obliges the workman to be careful in making the teeth equidistant. Then a small matter is taken from the point of each pallet, by filing off the back b r of the pallet. The tooth will now escape before it has moved through half a space.

From all that has been said on this particular, it appears that the interval between the pallets must comprehend a certain number of teeth, and half a space more.

The first circumstance to be considered in contriving a scapement is the angular motion that is intended to be given to the pendulum during the action of the wheel. This is usually called the *angle of scapement*, or the *angle of action*. Having fixed on an angle *a* that we think proper,

proper, we muft fecure it by the pofition and form of the face of the pallets. Knowing the number of teeth in the fwing-wheel, divide 180° by this number, and the quotient is the angle *b* of the wheel's motion during one vibration of the pendulum. In the line AM, joining the centres of the crutch and wheel, make SM to SA, and *s* M to *s* A, as the angle *a* to the angle *b*; and then, having determined how many teeth fhall be comprehended between the pallets, call this number *n*. Multiply the angle *b* by *n* + 1, and take the half of the product. Set off this half in the circumference of the wheel (at the points of the teeth) on each fide of the line joining the centres of the crutch and wheel, as at TB and TC. Through S and *s* draw SB and *s* C, and through B draw β B *b* perpendicular to SB, for the medium pofition of the face of the firft pallet; that is, for its pofition when the pendulum hangs perpendicular. In like manner, drawing *o* C *n* perpendicular to *s* C, we have the medium pofition of the fecond pallet. The demonftration of this conftruction is very evident from what has been faid.

We have hitherto fuppofed that the pendulum finifhes its vibration at the inftant that a tooth of the wheel efcapes from a pallet, and another tooth drops on the other pallet. But this is never, or fhould never be, the cafe. The pendulum is made to fwing fomewhat beyond the angle of fcapement: for if it do not when the clock is clean and in good order, but ftop precifely at the drop of a tooth, then, when it grows foul, and the vibration diminifhes, the teeth will not efcape at all, and the clock will immediately ftop. Therefore the force communicated by the wheels during the vibration within the limits of fcapement, muft be increafed fo as to make the pendulum *throw* (as the artifts term it) farther out; and a clock is more valued when it throws out confiderably beyond the angle of fcapement. There are good reafons for this The momentum of the pendulum, and its power to regulate the clock (which Mr Harrifon fignificantly called its *dominion*), is proportional to the width of its vibrations very nearly.

This circumftance of exceeding the angle of fcapement has a very great influence on the performance of the clock, or greatly affects the dominion of the pendulum. It is eafy to fee that, when the face β *b* of the leading pallet is a plane if the pendulum continue its motion to the right, from P toward Q, after the tooth B has dropped on it, the pallet will pufh the wheel back again, while the tooth flides outward on the pallet toward β. Such pallets therefore will make a *recoiling fcapement*, refembling, in this circumftance, the old pallet employed with the crown wheel, and will have the properties attached to this circumftance. One confequence of this is, that it is much affected by any inequalities of the maintaining power. It is a matter of the moft familiar obfervation, that a common watch goes flower when within a quarter of an hour of being down, when the action of the fpring is very weak, in confequence of its not pulling by a radius of the fufee. We obferve the fame thing in the beating of an alarum clock. Alfo if we at any time prefs forward the wheelwork of a common watch with the key, we obferve its beats accelerate immediately. The reafon of this is pretty plain. The balance, in confequence of the acceleration in the angle of fcapement, would have gone much farther, employing a confiderable time in the excurfion. This is checked abruptly, which both fhortens the vibration and the time employed in it. In the return of the pendulum, the motion is accelerated the whole way, along an arch which is fhorter than what correfponds to its velocity in the middle point; for it is again checked on the other fide, and does not make its full excurfion. Moreover, all this irregularity of force, or the great deviation from a refiftance to the excurfion proportional to the diftance from the middle point, is exerted on the pendulum when it is near the end of the excurfion, where the velocity being fmall, this irregular force acts long upon it, at the very time that it has little force wherewith to refift it. All temporary inequalities of force, therefore, will be more felt in this fituation of the balance than if they had been exerted in the middle of its motion. And although the regulating power of a pendulum greatly exceeds that of the light balances ufed in pocket watches, fomething of the fame kind may be expected even in pendulum clocks. Accordingly this appears by a feries of experiments made by Mr Berthoud, a celebrated watchmaker of Paris. A clock, with a half fecond pendulum weighing five drams, was furnifhed with a recoiling fcapement, whofe pallets were planes. The angle of fcapement was $5\frac{1}{2}$ degrees. When actuated with a weight of two pounds, it fwung 8°, and loft 15″ per hour; with four pounds, it fwung 10°, and loft 6″. Thus it appears that by doubling the maintaining power, although the vibration was increafed in confequence of the greater impulfe, the time was leffened 9″ per hour, viz. about $\frac{1}{400}$. It is plain, from what was faid when we defcribed the firft fcapement, that an increafe of maintaining power muft render the vibration more frequent. We faw, on that occafion, that, even when the gravity of the pendulum is balanced by a weight on the other end of the rod, the force of the wheels will produce a vibratory motion, and that an augmentation of this force will increafe it, or make the vibrations more rapid. The precife effect of any particular form of teeth can be learned only by computing the force on the pendulum in every pofition, and then conftructing the curve *r π* C of fig 1. The rapid increafe of the ordinates beyond thofe of the triangle ADC, forms a confiderable area DA π *o*, to compenfate the area π *o* C, and thus makes a confiderable contraction A π of the vibration, and a fenfible contraction $\frac{A\theta}{2}$ of the time.

Mr George Graham, the celebrated watchmaker in London, was alfo a good mathematician, and well qualified to confider this fubject fcientifically. He contrived a fcapement, which he hoped would leave the pendulum almoft in its natural ftate. The acting face of the pallet *a b c* (fig. 4.) is a plane. The tooth drops on *a* and efcapes from *c*, and is on the middle point *b* when the pendulum is perpendicular. Beyond *a*, the face of the pallet is an arch *a d*, whofe centre is A, the centre of the crutch. The maintaining power is made fo great as to produce a much greater vibration than the angle of active fcapement *a* A *c*. The confequence of this is that, when the tooth drops on the angle *a*, the pendulum, continuing its motion, carries the crutch along with it, and the tooth paffes on the arch *a d*, in a direction paffing through the centre of the crutch. This preffure can neither accelerate nor retard the motion

 tion

tion of the crutch and pendulum. As the pendulum was accelerated after it passed the perpendicular, by the other pallet, it will (if quite unobstructed) throw out farther than what corresponds to the velocity which it had in the middle point of its vibration; perhaps till the tooth passes from *a* to *e* on the circular arch of the pallet. But although it sustains no contrary action from the wheels during this excursion beyond the angle of scapement, it will not proceed so far, but will stop when the tooth reaches *d*; because there must be some resistance arising from the friction of the tooth along the arch *a d*, and from the clamminess of the oil employed to lubricate it: but this resistance is exceedingly minute, not amounting to $\frac{1}{8}$th of the pressure on the arch. Nay, we think that it appears from the experiments of Mr Coulomb that, in the case of such minute pressures on a surface covered with oil, there is no sensible retardation analogous to that produced by friction, and that what retardation we observe arises entirely from the clamminess of the oil. We are so imperfectly acquainted with the manner in which friction and viscidity obstruct the motions of bodies, that we cannot pronounce decisively what will be their effect in the present case. Friction does not increase much, if at all, by an increase of velocity, and appears like a fixed quantity when the pressure is given. This makes all motions which are obstructed by friction terminate abruptly. This will shorten both the length and the time of the outward excursion of the pendulum. The viscidity of the oil resists differently, and more nearly in the proportion of the velocities. The diminution of motion will not be in this proportion, because in the greater velocities it acts for a shorter time. Were this accurately the case, the resistance of viscidity would also be nearly constant, and it would operate as friction does. But it does not stop a motion abruptly, and the motions are extinguished gradually. Therefore, although viscidity must always diminish the extent of the excursion, it may so vary as not to diminish the time. We apprehend, however, that it generally does. But whatever happens in the excursion, the return will certainly be slower, and employ more time than if it had not been obstructed, because the velocity in every point is less than if perfectly free. The whole arch, consisting of a returning arch and an excursion on the other side, may be either slower or quicker, according as the compensation is complete or not, or is even overdone.

All these reflections occurred to Mr Graham; and he was persuaded that the time of the tooth's remaining on the arch *a d*, both ascending and descending, would differ very little from that of the description of the same arch by a free pendulum. The great causes of irregularity seemed to be removed, viz. the inequalities in the action of the wheels in the vicinity of the extremity of the vibration, where the pendulum having little momentum is, long in the same little space, exposed to their action. The derangement produced by any force depends on the time of its action, and therefore must be greatest when the motion is slowest. The pendulum gets its impulse in the very middle of its vibration, where its velocity is the greatest; and therefore the inequalities of the maintaining power act on it only for a short time, and make a very trifling alteration in the time of its describing the arch of scapement. Beyond this, it is nearly in the state of a free pendulum; nay, even though it be affected by an inequality of the maintaining power, and it be accelerated beyond its usual rate in that arch, the chief effect of this will be to cause it to describe a larger arch of excursion. The shortening of the time of this description by the friction will be the same as before, happening at the very end of the excursion; but the return will be more retarded by the friction on a longer arch. And, by this, a compensation may be made for the trifling contraction of the time of describing the arch of scapement.

This circumstance of giving the impulse in the middle of the vibration, where its time of action is the smallest possible, and whereby the pendulum is so long left free from the action of the wheels, is of the very first importance in all scapements, and should ever be in the mind of the mechanician. When this is adhered to, the form of the face *a b c* is scarcely of any moment. Much has been written on this form, and many attempts have been made to make it such that the action of the wheels shall be proportional to the action of gravity. To do this is absolutely impossible. Mr Graham made them planes, not only because of easiest execution, but because a plane really conspires pretty well with the change of gravity. While the pendulum moves from Q to P (fig. 3.), the force of gravity, acting in the direction QP, is continually diminishing. So is the accelerating power of the pallet from *a* to *b*. When the pendulum rises from P to R, a force in the opposite direction RP continually increases. This is analogous to the continual diminution of a force in the direction PR. Now we have such a diminution of such a force, in the action of the pallet from *b* to *c*, and such an augmentation in the action of the other pallet.

For all these reasons, this construction of a scapement appeared very promising. Mr Graham put it in practice, and it answered his most sanguine expectation, and is now universally adopted in all nice clocks. Mr Graham, however, did not think it prudent to cause a tooth to drop on the very angle *a* of the pallet. He made it drop on a point *f* of the arch of excursion. This has also the advantage of diminishing the angle of action, which we have proved to be of service. It requires, indeed, a greater maintaining power; but this can easily be procured, and is less affected by the changes to which it is liable by the effect of heat and cold on the oil. Our observations on the effects of friction and viscidity in the arch *a d* seem to be confirmed by the observations of several artists, who agree in saying that a great increase of maintaining power increases the vibrations, but makes them perceptibly slower. When they wrote, much oil was applied to diminish the friction on the arch of repose; but, since that time, the rubbing parts were made such as required no oil, and this retardation disappeared. In the clock of the transit room of the Royal Observatory, the angle of action seldom exceeds one-third of the swing of the pendulum. The pallets are of oriental ruby, and the wheel is of steel tempered to the utmost degree of hardness. This clock never varies a whole second from equable motion in the course of five days.

This contrivance is known by the name of the DEAD BEAT, the DEAD SCAPEMENT; because the seconds index stands still after each drop, whereas the index of a clock with a recoiling scapement is always in motion, hobbling backward and forward.

These ſcapements, both recoiling and dead beat, have been made in a thouſand forms; but any perſon tolerably acquainted with mechanics, will ſee that they are all on the ſame principles, and differ only in ſhape or ſome equally unimportant circumſtance. Perhaps the moſt convenient of any is that repreſented in fig. 5. where the ſhaded part is the crutch, made of braſs or iron, and A and B are two pieces of agate, flint, or other hard ſtone, cut into the proper ſhape for a pallet of either kind, and firmly fixed in proper ſockets. They project half an inch, or thereabouts, in front of the crutch, ſo that the ſwing wheel is alſo before the crutch, diſtant about $\frac{1}{10}$th of an inch or ſo. Pallets of ruby, driven by a hard ſteel ſwing wheel, need no oil, but merely to be once rubbed clean with an oily cloth.

Sometimes the wheel has pins inſtead of teeth. They are ranged round the rim of the wheel, perpendicular to its plane, and both pallets are on one ſide of the wheel, ſtanding perpendicular to its plane. One of theſe pins drops from the firſt to the ſecond pallet at once. The pallets are placed on two arms, as in fig. 6. in which caſe the pins are alternately on different ſides of the wheel; or on one, as in fig. 7. By the motion of the pendulum to the right, the pin (in fig. 7.), after reſting on the concave arch *d a*, acts on the face *a c*, and drops from *c* on the other concave arch *i g*, which continues to move a little way to the right. It then returns, and the pin ſlides and acts on the pallet *i b*, and eſcapes at *b*; and the next pin is then on the arch of repoſe *d a*.

It being evident that the recoiling ſcapement accelerates the vibrations beyond the rate of a free pendulum, and it alſo appearing to many of the firſt artiſts that the dead ſcapement retards them, they have attempted to form a ſcapement which ſhall avoid both of theſe defects, by forming the arches *a d*, *i g*, ſo as to produce a very ſmall recoil. Mr Berthoud does this in a very ſimple manner, by placing the centre of *a d* at a ſmall diſtance from that of the crutch, ſo as to make the riſe of the pallet above the concentric arch about one-third of the arch itſelf. Applying ſuch a crutch to the light pendulum mentioned in a former paragraph, he found that doubling, and even trebling the maintaining power, produced no change in the time of vibration, though it increaſed the width from 8° to 12° and 14°. We have no doubt of the efficacy of this contrivance, and think it very proper for all clocks which require much oil, ſuch as turret clocks, &c. But we apprehend that no rule can be given for the angle that the recoiling arch ſhould make with the concentric one. We imagine that this depends entirely on the ſhare which friction and oil have in producing the retardation of the dead beat.

Other artiſts have endeavoured to avoid the inconveniences of friction and oil on the arch of repoſe in another way. Inſtead of allowing the tooth of the wheel to drop on the back of the pallet, which we called the *arch of excurſion*, and others call the *arch of repoſe*, it drops on a detent *o t a* (fig. 8.), of which the part *t a* is part of an arch whoſe centre is A, the centre of the crutch, and the part *t o* is in the direction of the radius. This piece does not adhere to the pallet, but is on the end of an arm *o* A, which turns round the axis A of the crutch on fine pivots: it is made to apply itſelf to the back of the pallet by means of a ſlender ſpring A *p*, attached to the pallet, and preſſing inward on a pin *p*, fixed in the arm of the detent. When ſo applied, its arch *t a* makes the repoſe, and its point *a* makes a ſmall portion of the face *a c* of the pallet.

Watch-work.

The action of this apparatus is very eaſily underſtood. When a tooth eſcapes from the ſecond pallet, by the motion of the pendulum from the left to the right, another tooth drops on this pallet (which the figure ſhews to be the firſt or leading pallet) at the angle *t*, and reſts on the ſmall portion *t a* of an arch of repoſe. But the crutch, continuing its motion to the right, immediately quits the arm *o* A, carrying the pallet *a c r* along with it, and leaving the wheel locked on the detent *o t a*. By and bye the pendulum finiſhes its excurſion to the right, and returns. When it enters the arch of action, the pallet has applied itſelf to the detent *o t a*, and withdraws it from the tooth. The tooth immediately acts on the face *a c* of the pallet, and reſtores the motion loſt during the laſt vibration. The uſe of the ſpring is merely to keep the detent applied to the pallet without ſhaking. It is a little bent during their ſeparation, and adds ſomething of an oppoſing force to the aſcent of the pendulum on the other ſide of the wheel, and accelerates its return. A ſimilar detent on the back of the ſecond pallet performs a ſimilar office, ſupporting the wheel while the pendulum is beyond the arch of ſcapement, and quitting it when the pendulum enters that arch.

We do not know who firſt practiſed this very ingenious and promiſing invention. Mr Mudge certainly did ſo early as 1753 or 1754. Mr Berthoud ſpeaks obſcurely of contrivances of the ſame nature. So does Le Roy, and (we think) Le Paute. We ſay that it is very promiſing. Friction is almoſt annihilated by transferring it to the pivots at A; ſo that, in the excurſion beyond the angle of ſcapement, the pendulum ſeems almoſt free. Indeed ſome artiſts of our acquaintance have even avoided the friction of the pivots at A, by making the arm of the detent a ſpring of conſiderable thickneſs, except very near to A, where it is made very thin and broad. But we do not find that this conſtruction, though eaſily executed, and ſuſceptible of great preciſion and ſteadineſs of action, is much practiſed. We preſume that the performance has not anſwered expectations. It has not been ſuperior to the incomparably more ſimple dead ſcapement of Graham. Indeed we think that it cannot. A part of the friction ſtill remains, which cannot be removed; namely, while the arch *t a* is drawn from between the tooth and pallet. Nay, we apprehend that ſomething more than friction muſt be overcome here. The tooth is apt to force the detent outward, unleſs the part *t a* be a little elevated at its point *a* like a claw, above the concentric arch, and the face of the tooth be made to incline forward, ſo as to fit this ſhape of the detent. This will conſume ſome force, when the momentum of the pendulum is by no means at its maximum. Should the clock be foul, and the excurſions beyond ſcapement be very ſmall, this diſturbance muſt be exceedingly pernicious. But we have a much greater objection. During the whole excurſion beyond ſcapement, there is a new force of a ſpring acting on the pendulum, which deviates conſiderably from the proportions of the accelerating power of gravity. It does not commence its action till the detent ſeparates from the arm of the crutch. Then the ſpring of the detent acts as a retarding force

against

against the excursion of the pendulum, now on the other side, bringing it sooner to rest, and then accelerating it in its way back to the beginning of the arch of scapement. In short, this construction should have the properties of a recoiling scapement. We got a clock-maker to make some experiments on one which he had made for an amateur, which fully confirmed our conjecture. When the detent spring was strong, an increase of maintaining power made the vibrations both wider and more rapid. The artist reduced the strength of the spring till this effect was rendered very small. It might perhaps be quite removed by means of a still weaker spring: But the spring was already so weak that a hard step on the floor of the room did sometimes disengage the detent from the wheel. It appears, therefore, that nothing can be reasonably expected from this construction that is not as well performed by the dead scapement of Mr Graham, of much easier execution, and more certain performance.

Very similar to this construction (at least in the excursion beyond the angle of scapement) is the construction of Mr Cumming, and it has the same defects. His pallets are carried, as in the one described, by the crutch. The detents press on them behind by their weight only: therefore, when the tooth is locked on the detent of one pallet, its weight is taken off from the pendulum on that side, and the weight of the detent on the other side opposes the ascent, and accelerates the descent of the pendulum.

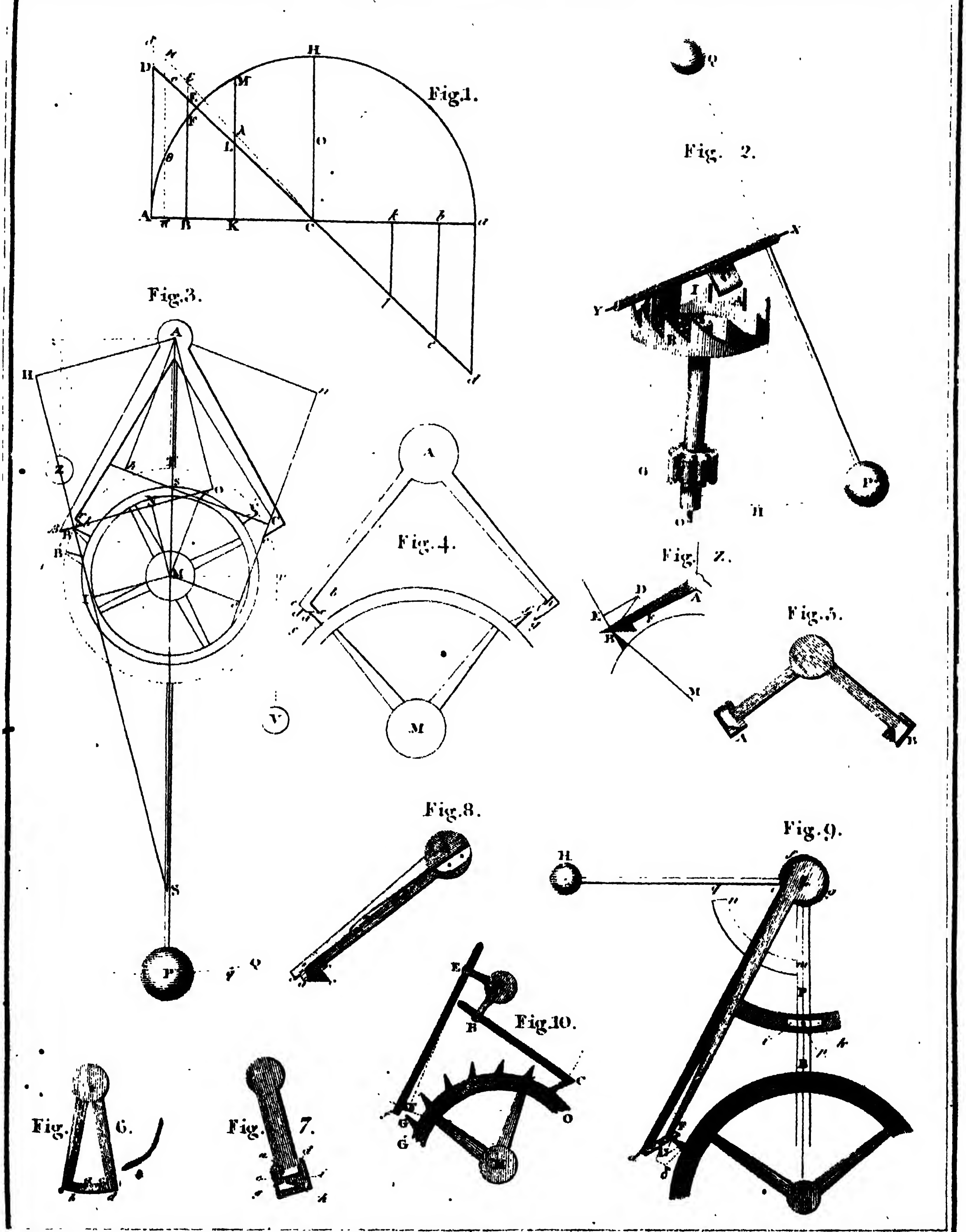
Mr Cumming executed another scapement, consisting, like those, of a pallet and detent. But the manner of applying the maintaining power is extremely different in principle from any yet described. It is exceedingly ingenious, and seems to do all that is possible for removing every source of irregularity in the maintaining power, and every obstruction to free motion arising from friction and oil in the scapement. For this reason we shall give such an account of its essential circumstances as may suffice to give a clear conception of its manner of acting, and its good properties and defects; but referring the inquisitive reader to Mr Cumming's Elements of Clock and Watch Work, published in 1766, for a more full account.

In the scapements last described, the pallets were fixed to the crutch and pendulum, and the maintaining power, during its action, was applied to the pendulum by means of the pallets, in the same way as in ordinary scapements. The detents were unconnected with the pendulum. and it was free during the whole excursion. In the present scapement both the pallets and detents are detached from the pendulum, except in the moment of unlocking the wheel; so that the pendulum may be said to be free during its whole vibration, except during this short moment.

ABC (fig. 9.) represents a portion of the swing wheel, of which O is the centre, and A one of the teeth; Z is the centre of the crutch, pallets, and pendulum. The crutch or detents is represented of a form resembling the letter A, having in the circular cross piece a slit *i k*, also circular, Z being the centre. This form is very different from Mr Cumming's, and inferior to his, but was adopted here in order to avoid a long description. The arm ZF forms the first detent, and the tooth A is represented as locked on it at F. D is the first pallet on the end of the arm Z *d* moveable round the same centre with the detents, but moveable independently of them. The arm *d c*, to which the pallet D is attached, lies altogether behind the arm ZF of the detent, being fixed to a round piece of brass *e f g*, which has pivots turning concentric with the verge or axis of the pendulum. To the same round piece of brass is fixed the horizontal arm *e* H. carrying at its extremity the ball H, of such size, that the action of the tooth A on the pallet D is just able (but without any risk of failing) to raise it up to the position here drawn. ZP*p* represents the fork, or the pendulum rod, behind both detent and pallet. A pin *p* projects forward, coming through the slit *i k*, without touching the upper or under margin of it. There is also attached to the fork the arm *m n* (and a similar one on the other side), of such length that, when the pendulum rod is perpendicular, as is represented here, the angular distance of *n q* from the rod *e q* H is precisely equal to the angular distance of the left side of the pin *p* from the left end *i* of the slit *i k*.

The mode of action on this apparatus is abundantly simple. The natural position of the pallet D is at *s*, represented by the dotted lines, resting on the back of the detent F. It is naturally brought into this position by its own weight, and still more by the weight of the ball H. The pallet D, being set on the fore side of the arm at Z, comes into the same plane with the detent F and the swing-wheel. It is drawn, however, in the figure in another position. The tooth C of the wheel is supposed to have escaped from the second pallet, on which the tooth A immediately engages with the pallet D, situated at *s*, forces it out, and then rests on the detent F, the pallet D leaning on the tip of the tooth. F is brought into this situation in a way that will appear presently. After the escape of C, the pendulum, moving down the arch of semivibration, is represented as having attained the vertical position. Proceeding still to the left, the pin *p* reaches the extremity *i* of the slit *i k*; and, at the same instant, the arm *n* touches the rod *e* H in *q*. The pendulum proceeding a hair's breadth further, withdraws the detent F from the tooth, which now even pushes off the detent, by acting on the slant face of it. The wheel being now unlocked, the tooth following C on the other side acts on its pallet, pushes it off, and rests on its detent, which has been rapidly brought into a proper position by the action of A on the slant face of F. It was a similar action of C on its detent, in the moment of escape, which brought F into a fit position for locking the wheel by the tooth A. The pendulum still going on, the arm *m n* carries the weight of the ball H, and the pallet connected with it, and it comes to rest before the pin *p* again reaches the end of the slit, which had been suddenly withdrawn from it by the action of A on the slant face of F. The pendulum now returns towards the right, loaded on the left with the ball H, which restores the motion which it had lost during the last vibration. When, by its motion to the right, the pin *p* reaches the end *k* of the slit *i k*, it unlocks the wheel on the right side. At the same instant the weight H ceases to act on the pendulum, being now raised up from it by the action of a tooth like B on the pallet D.

Let us now consider the mechanism of these motions. The prominent feature of the contrivance is the almost complete disengagement of the regulator from the wheels.



D. Lizars. Sculp.

Fig. 11.

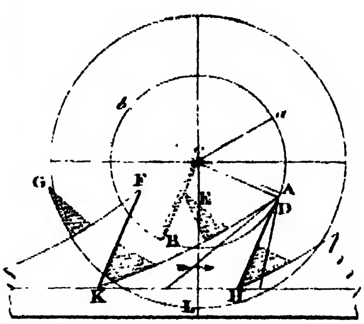


Fig. 12.

Fig. 13.

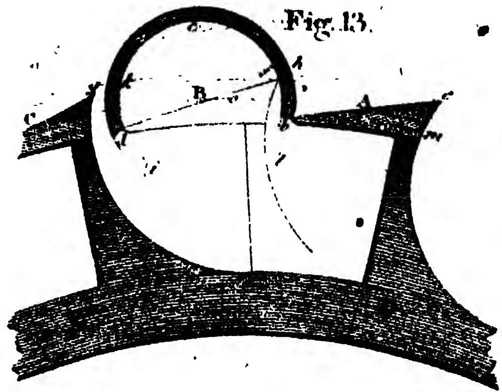


Fig. 14.

Fig. 15.

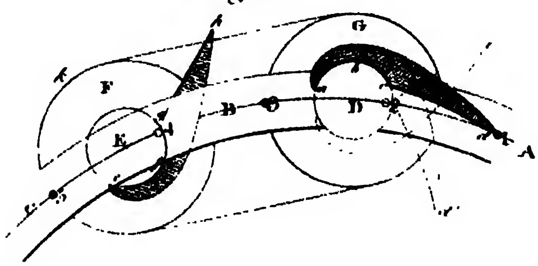


Fig. B. 15.

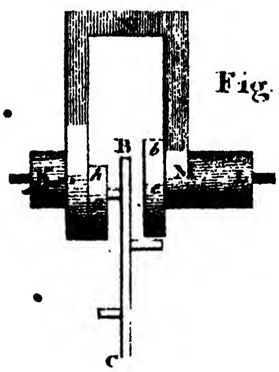


Fig. B. 13.

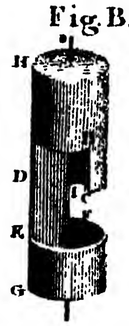


Fig. C.

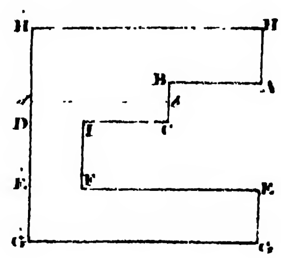


Fig. 19.

Fig. 16.

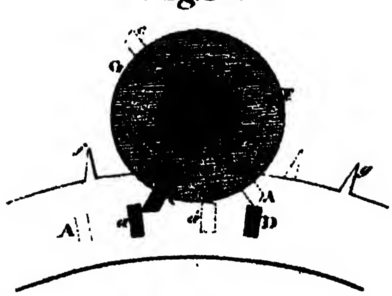


Fig. 17.

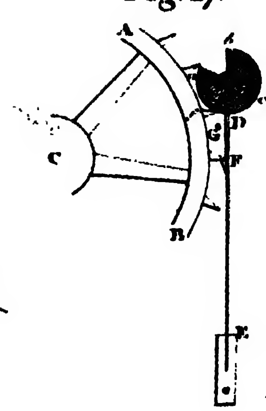


Fig. 18.

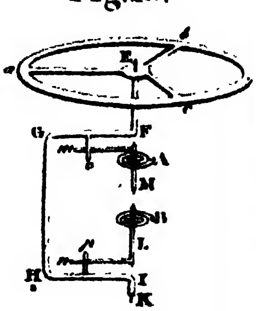


Fig. 1.

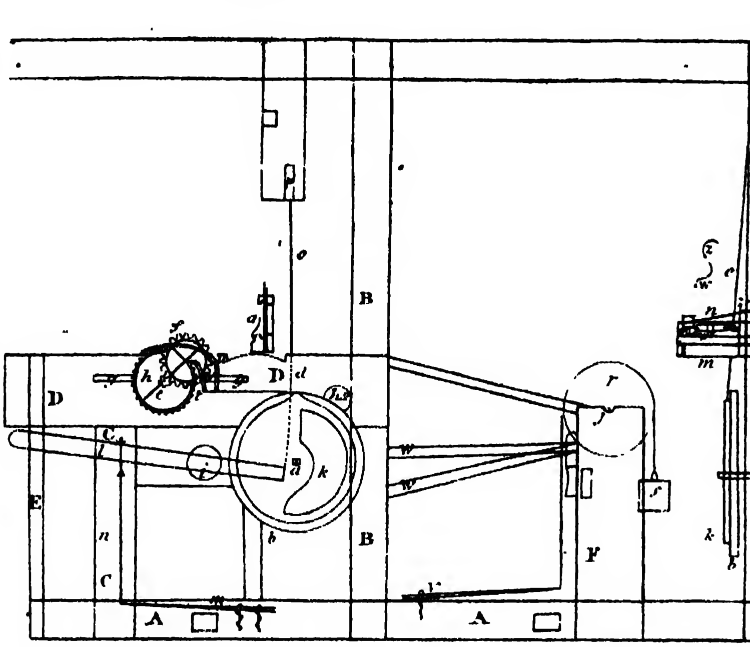
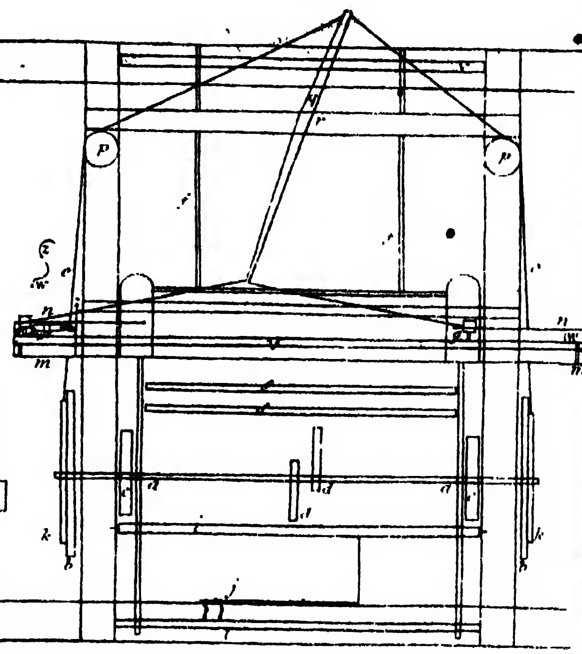


Fig. 2.



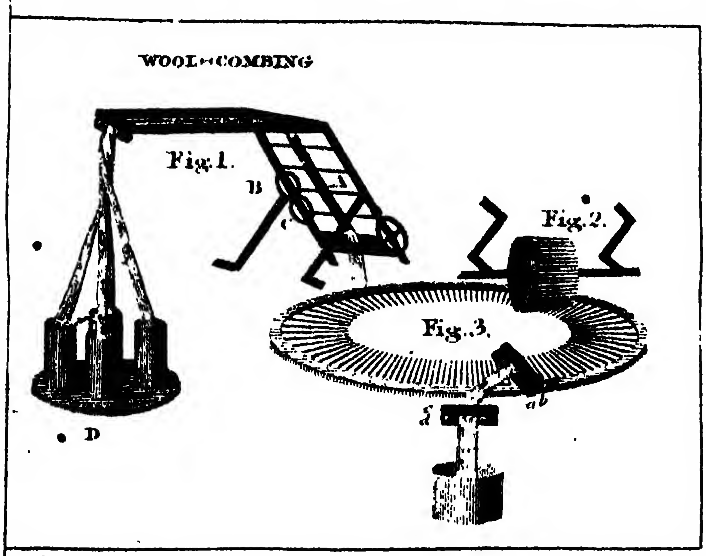
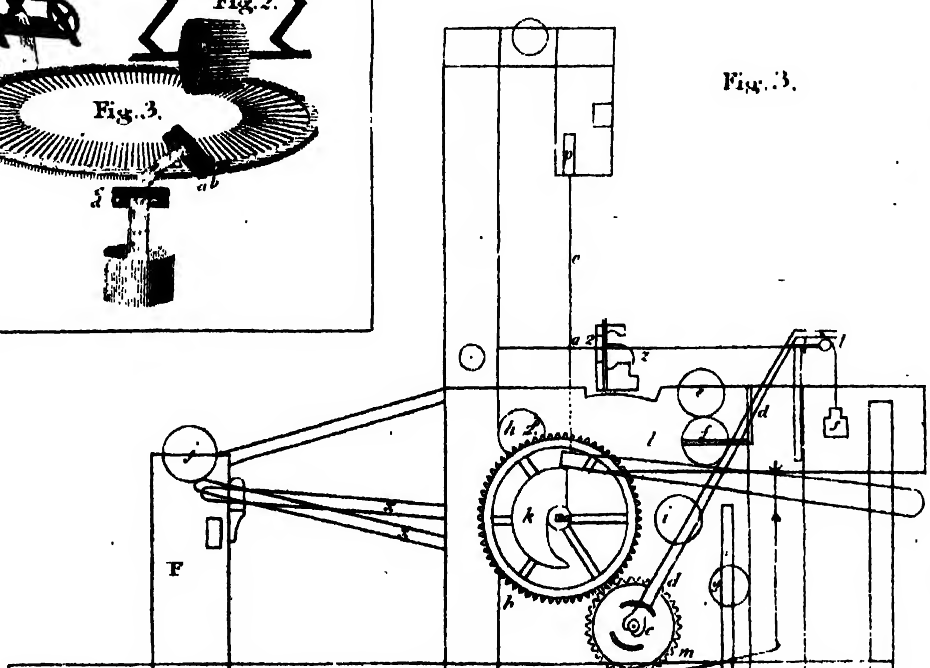


Fig. 3.



The wheels, indeed, act on the pallets; but the pallets are then detached from the pendulum. The ſole uſe of the wheel is to raiſe the little weights while the pendulum is on the other ſide, in order to have them in readineſs at the arrival of the pendulum. They are then laid on the pendulum, and ſupply an accelerating force, which reſtores to the pendulum the momentum loſt during the preceding vibration. Therefore no inequalities in the action of the wheel on the pallets, whether ariſing from friction or oil, has any effect on the maintaining power. It remains always the ſame, namely, the rotative momentum of the two weights. The only circumſtance, in which the irregularity of the action of the wheels can affect the pendulum is at the moment of unlocking. Here indeed the regulator may be affected; but this moment is ſo ſhort, in compariſon with other ſcapements, that it muſt be conſidered as a real improvement.

It is very uncandid to refuſe the author a claim to the character of an ingenious artiſt on account of this contrivance, as has been done by a very ingenious univerſity Profeſſor, who taxes Mr Cumming with ignorance of the *firſt elements of mechanics*, and ſays that the beſt thing in his book is his advice to ſuſpend the pendulum from a great block of marble, firmly fixed in the wall *. This is certainly a good advice, and we doubt not but that the Profeſſor's clock would have performed ſtill better if he had condeſcended to follow it. It is ſtill leſs candid to queſtion the originality of the invention. We know for certain that it was invented at a time and place where the author *could* not know what had been done by others. It would have been more like the urbanity of a well educated man to have acknowledged the genius, which, without ſimilar advantages, had done ſo much.

* See *Ludlam's Eſſay*.

But, while we thus pay the tribute of juſtice to Mr Cumming, we do not adopt all his opinions. The clock has the ſame defects of the former in reſpect of the laws of the force which accelerates the pendulum. The ſudden addition of the ſmall weight, and this almoſt at the extremity of the vibration, would derange it very much, if the addition were ſuſceptible of any ſenſible variation. The irregularity of the action of the wheels *may* ſenſibly affect the motion during the unlocking, when the clock is foul, and the pendulum *juſt* able to unlock; for any diſturbance at the extremity of the vibration greatly affects the time. We acknowledge that the parts which we here ſuppoſe to be foul may not be ſo in the courſe of twenty years, theſe parts being only the pivots of the ſcapement. The great defect of the ſcapement is its liableneſs to unlock by any jolt. It is more ſubject to this than the others already mentioned. This riſk is much increaſed by the ſlender make of the parts, in Mr Cumming's drawings, and in the only clock of the kind we have ſeen; but this is not neceſſary; and it ſhould be avoided for another reaſon; the interpoſing ſo many ſlender and crooked parts between the moving power and the pendulum weakens the communication of power, and requires a much more powerful wheelwork.

All theſe, however, are ſlight defects, and only the laſt can be called a fault. The clocks made on this principle have gone remarkably well, as may be ſeen by the regiſters of his majeſty's private obſervatory. But the greateſt objection is, that they do not perform better than a well-made dead ſcapement; and they are vaſtly more troubleſome to make and to manage. This is ſtrictly true, and is a ſerious objection. The fact is, that the dominion of a heavy pendulum is ſo great, that if *any one* of the ſcapements now deſcribed be well executed with pallets of agate, and a wheel of hard ſteel, and if the pendulum be ſuſpended agreeably to Mr Cumming's advice, there is hardly any difference to be obſerved in their performance. We ſhall content ourſelves with a ſingle proof of this from fact. The clock invented by the celebrated Harriſon is *at leaſt equal* in its performance to any other. Friction is almoſt annihilated, and no oil is required. It went fourteen years without being touched, and during that time did not vary one complete ſecond from one day to another, nor ever deviated half a minute by accumulation from equable motion: Yet the ſcapement, in ſo far as it reſpects the law of the accelerating force, deviates more from the proportion of the ſpaces than the moſt recoiling ſcapement that ever was put to a good clock. It is ſo different from all hitherto deſcribed, both in form and principle, that we muſt not omit ſome account of it, and with it we ſhall conclude our ſcapements for clocks.

Let GDO repreſent the ſwing-wheel, of which M is the centre. A is the verge or axis of the pendulum. It has two very ſhort arms AB, AE. A ſlender rod BC turns on fine pivots in the joint B, and has at its extremity C a hook or claw, which takes hold of a tooth D of the ſwing-wheel when the pendulum moves from the right ſide to the left. This claw, when at liberty, ſtands at right angles, or, at leaſt, in a certain determinate angle, with regard to the arm AB; and when drawn a little from that poſition, it is brought back to it again by a very ſlender ſpring. The arm AE is furniſhed with a detent EF, which alſo, when at liberty, maintains its poſition on the arm by means of a very ſlender ſpring.

Let us now ſuppoſe that the tooth D is preſſing on the claw C, while the pendulum is moving to the right. The joint B yields, by its motion round A, to the preſſure of the tooth on the claw. By this yielding, the angle ABC opens a little. In the mean time, the ſame motion round A cauſes the point F of the detent on the other ſide to approach the circumference of the wheel in the arch of a circle, and the tooth G at the ſame time advances. They meet, and the point of G is lodged in the notch under the projecting heel *f*. When this takes place, it is evident that any farther motion of the point E round A muſt puſh the tooth G a little backward, by means of the detent EF. It cannot come any nearer to the wheel, becauſe the point of the tooth ſtops the heel *f*. The inſtant that F puſhes G back, the tooth D is withdrawn from the claw C, and C flies out, by the action of its ſpring, and reſumes its poſition at right angles to BA; and the wheel is now free from the claw, but is puſhing at the detent F (c). The pendulum, having

(c) The reader may here remark the manner in which the preſſure of the tooth G on the detent is transferred to the joint E by the intervention of the ſhank FE, and from the joint E to the pendulum rod, by the intervention

ving finiſhed its excurſion to the right (in which it cauſes the wheel to recoil by means of the detent F), returns toward the left. The wheel now advances again, and, by preſſing on F, aids the pendulum through the whole angle of ſcapement. By this motion the claw C deſcribes an arch of a circle round A, and approaches the wheel, till it take hold of another tooth, namely, the one following D, and pulls it back a little. This immediately frees the detent F from the preſſure of the tooth G, and it flies out a little from the wheel, reſuming its natural poſition by means of its ſpring. Soon after, the motion of the pendulum to the left ceaſes, and the pendulum returns; D pulling forward the hook C to aid the pendulum, and the former operation is repeated, &c. &c.

Such is the operation of the pallets of Harriſon and Hindley. Friction is almoſt totally avoided, and oil entirely (D). The motion is given to the pendulum by a fair pull or puſh, and the teeth of the wheel only apply themſelves to the detents without rubbing. There is no drop, and the ſcapement makes no noiſe, and is what the artiſts call *a ſilent ſcapement*. The mechanician will readily perceive, that by properly diſpoſing the arms AB, AE, and diſpoſing the pallets on the circumference of the wheel, the law, by which the action of the wheel on the pendulum is regulated, may be greatly varied, ſo as to harmonize, as far as the nature of ſcapement, alternately puſhing and pulling, will admit, with the action of gravity.

But this is evidently a recoiling ſcapement, and one of the worſt kind; for the recoil is made at the very confines of the vibration, where every diſturbance of the regular cycloidal vibration occaſions the greateſt diſturbance to the motion. Yet this clock kept time with moſt unexampled preciſion, far excelling all that had been made before, and equal to any that have been made ſince. This is entirely owing to the immenſe ſuperiority of the momentum of the pendulum over the maintaining power.

II. *Of Scapements for a Watch.*

THE execution of a proper ſcapement for watches is a far more delicate and difficult problem than the foregoing, on account of the ſmall ſize, which requires much more accurate workmanſhip, becauſe the error of the hundredth part of an inch has as great a proportion to the dimenſions of the regulator as an inch in a common houſe clock. It is much more difficult on another account. We have no ſuch means of accumulating ſuch a dominion (to uſe Mr Harriſon's expreſſive term) over the wheel-work in the regulator of a watch as in that of a clock. The heavieſt balance that we can employ, without the certainty of ſnapping its pivots by every ſlight jolt, is a mere trifle, in compariſon with the pendulum of the moſt ordinary clock. A dozen or twenty grains is the utmoſt weight of the balance, even of a very large pocket watch. The only way that we can accumulate any notable quantity of regulating power in ſuch a ſmall pittance of matter is by giving it a very great velocity. This we do by accumulating all its weight in the rim, by giving it very wide vibrations, and by making them extremely frequent. The balance-rim of a middling good watch ſhould paſs through at leaſt ten inches in every ſecond. Now, when we reflect on the ſmall momentum of this regulator, the inevitable inequalities of the maintaining power, and the great arch of vibration on which theſe inequalities will operate, and the comparative magnitude even of an almoſt inſenſible friction or clamminеſs, it appears almoſt chimerical to expect any thing near to equability in the vibrations, and incredible that a watch can be made which will not vary more than one beat in 86400. Yet ſuch have been made. They muſt be conſidered as the moſt maſterly exertions of human art. The performance of a reflecting teleſcope is a great wonder: the worſt that can find a market muſt have its mirrors executed without an error of the ten thouſandth part of an inch; but we now know that this accuracy is attained almoſt in ſpite of us, and that we ſcarcely *can* make them of a worſe figure. But the caſe is far otherwiſe in watch work. Here all thoſe wonderful approaches to perfection are the reſults of rational diſcuſſion, by means of ſound principles of ſcience; and, unleſs the artiſt who puts theſe principles into practice be more than a mere copyiſt, unleſs the principles themſelves are perceived by him, and actually direct his hand, the watch may ſtill be good for nothing. Surely, then, this is a liberal art, and far above a manual knack. The ſtudy of the means by which ſuch wonders are ſteadily effected, is therefore the ſtudy of a gentleman.

In the account given above of the ſcapements for pendulums, we aſſumed as one leading principle that *the natural vibrations of a pendulum are performed in equal times, whether wide or narrow.* This is ſo nearly true, when the arches on each ſide of the perpendicular do not exceed four degrees, that the retardation of the wider arches within that limit will not become ſenſible, though accumulated for a long time. The common ſcapement with a plane face of the pallet, helps to correct even this ſmall inequality much better than the niceſt form of the cycloidal cheeks propoſed by Huyghens.

In watch-work we aſſume a ſimilar principle, namely, that *the oſcillations of a balance, urged by its ſpring, and undiſturbed*

tion of the arm EA. This communication of preſſure is preciſely the ſame that we made uſe of in explaining the common ſcapement. MG, FE, and EA, in this fig. 10. are performing the offices which we then gave to the lines MB, BH, and HA, in fig. 3. Harriſon's pallet realiſes the abſtract theory.

(D) Mr Harriſon was at firſt by profeſſion a carpenter in a country place. Being extremely ingenious and inventive, he had made a variety of curious wooden clocks. He made one, in particular, for a turret in a gentleman's houſe. Its expoſure made it waſte oil very faſt, and the maker was often obliged to walk two or three miles to renew it, and got nothing for his trouble. In trudging home, not in very good humour, he pondered with himſelf how to make a clock go without oil. He changed all his pinion leaves into rollers; which anſwered very well. But the pallets required it more than any other part. After various other projects, he contrived thoſe now repreſented, where there was no friction, and no oil is wanted. The turret clock continued to go without being touched till Mr Harriſon left the country.

Watch-work.

undisturbed by all foreign forces are performed in equal times, whether they be wide or narrow. This principle was assumed by the celebrated mechanician Dr Robert Hooke, on the authority of many experiments which he had made on the bending and unbending of springs. He found that the force necessary for retaining a spring in any constrained position was proportional to its tension, or deflection from its natural form. He expressed this in an anagram, which he published about the year 1660, in order to establish his claim to the discovery, and yet conceal it, till he had made some important application of it. When the anagram was explained some years afterwards, it was, "*Ut tensio, sic vis.*" Dr Hooke thought of applying this discovery to the regulation of watch movements. For, if a slender spring be *properly* applied to the axis of a watch balance, it will put that balance in a certain determinate position. If the balance be turned aside from this position, it seems to follow that it will be urged back toward it by a force proportional to its distance from it. He immediately made the application to an old watch, which he afterward gave to Dr Wilkins, Bishop of Chester. This was in 1658. Its motion was so amazingly improved, that Hooke was persuaded of the perfection of his principle, and thought that nothing was now wanting for making a watch of this kind a perfect chronometer but the hand of a good workman. For his watch seemed almost perfect, though made in a small country town, in a very coarse manner. Mr Huyghens also claims this discovery. He published his claim about the year 1675, and proposed to make watches for discovering the longitude of a ship at sea. But there is the most unquestionable evidence of Dr Hooke's priority by fifteen years, and of his having made several watches of this kind. One of them was in the possession of his majesty king Charles II. Dr Hooke's first balance spring was straight, and acted on the balance in a very imperfect manner. But he soon saw the imperfections, and made several successive alterations; and, among others, he employed the cylindrical spiral now employed by Mr Arnold; but he gave it up for the flat spiral: and the king's watch had one of this kind before Mr Huyghens published his invention. His project of longitude watches had been carried on along with Lord Brouncker and Sir Robert Moray, and they had quarrelled some years before that publication. See WATCH, *Encycl.*

But both Dr Hooke and Mr Huyghens were too sanguine in their expectations. We, by no means, have the evidence for the truth of this principle that we have for the accelerating action of gravity on a pendulum. It rests on the nicety and the propriety of the experiments; and long experience has shewn that it is sensibly true only within certain limits. The demonstrations by which Bernoulli supports the unqualified principle of Mr Huyghens, proceed on hypothetical doctrines concerning the nature of elasticity. And even these shew that the law of elasticity which he assumed was selected, not because founded on simpler principles than any other, but because it was consistent with the experiments of Hooke and Huyghens. Besides, although this should be the true law of a spring, it does not follow that this spring, applied in *any way* to the axis of a balance, will urge that balance agreeably to the same law: and if it did, it still does not follow that the oscillations of the balance will be isochronous; for the spring has to move not only the balance but also the spring. Part of the restoring force of the spring is employed in restoring it rapidly to its quiescent shape, and thus enabling it to *follow and still impel* the yielding balance. It is therefore only the surplus which is employed in actually moving the balance, and it is uncertain whether this surplus varies according to the same law, being always the same proportion of the whole force of the spring. We find it an extremely difficult problem to determine the law of variation of this surplus, even in the simplest form of the spring; nay, it is by no means an easy problem to determine the law of oscillation of a spring, unloaded with any balance; and we can easily shew that there are such forms of a spring, that although the velocity with which the different parts approach to their quiescent position be exactly as their excursion from it, this is by no means the law of velocity which this spring will produce in a balance. The matter of fact is, that when the spring is a simple straight steel wire, suspending the balance in the direction of its axis, the motions of it, if not immoderate, are precisely agreeable to Huyghens's and Hooke's rule; and that the motion of a balance urged by a spring wound up into a flat, or a cylindrical spiral, as in common watches, and those of Arnold, deviates sensibly from it, unless a certain analogy be preserved between the length and the elasticity of the spring. If the spring be immoderately long, the wide vibrations are slower than the narrow ones; and the contrary is observed when the spring is immoderately short. A certain taper, or gradual diminution of the spring, is also found to have an effect in equalizing the wide and narrow vibrations. There is also a great difference between the force with which a part of the spring unbends itself, and the action of that force in urging the balance round its axis; and the performance of many watches, good in other respects, is often faulty from the manner in which this unbending force is employed.

But, since these corrections are in our power in a considerable degree, we may suppose them applied, and the true motion (which we shall call the cycloidal) attained; and we may then adapt the construction of the scapement to the preserving this motion undisturbed. And here we must see at once that the problem is incomparably more delicate than in the case of pendulums. The vibrations must be very wide, and the angular motion rapid, that it may be little affected by external motions. The smallest inequalities of maintaining power acting through so great a space, must bear a considerable proportion to the very minute momentum of a watch balance. Oil is as clammy on the pallets of a watch as on those of a clock; a viscidity which would never be felt by a pendulum of 20 pounds weight will stop a balance of 20 grains altogether. For the same reason, it is evident that any impropriety in the form of the pallet must be incomparably more pernicious than in the case of a pendulum; the deviation which this may occasion from a force proportional to the angular distance from the middle point, must bear a great proportion to the whole force.

The common recoiling scapement of the old clocks still holds its place in the ordinary pocket watches, and answers all the common purposes of a watch very well. A well finished watch, with a recoiling scapement, will

will keep time within a minute in the day. This is enough for the ordinary affairs of life. But such watches are subject to great variation in their rate of going, by any change in the power of the wheels. This is evident; for if the watch be held back, or pressed forward, by the key applied to the fusee square, we hear the beating greatly retarded or accelerated. The maintaining power, in the best of such watches, is never less than one-fifth of the regulating power of the spring. For, if we take off the balance spring, and allow the balance to vibrate by the impulse of the wheels alone, we shall find the minute hand to go forward from 25 to 30 minutes per hour. Suppose it 30. Then, since the wheels act through equal spaces with or without a spring, the forces are as the squares of the acquired velocities. (DYNAMICS, *Suppl.* n° 95) The velocity in this case is double; therefore the accelerating force is quadruple, and the force of the spring is three times that of the wheels. If the hand goes forward 25 minutes, the force of the wheels is about one-fifth of that of the spring. This great proportion is necessary, as already observed, that the watch may go as soon as unstopped.

We have but little to say on this scapement; its principle and manner of action, and its good and bad qualities, being the same with those of the similar scapement for pendulums. It is evident that the maintaining power being applied in the most direct manner, and during the whole of the vibration, it will have the greatest possible influence to move the balance. A given mainspring and train will keep in motion a heavier balance by means of this scapement than by any other. But, on the other hand, and for the same reason, the balance has less dominion over the wheel-work, and its vibrations are more affected by any irregularities of the wheel-work. Moreover, the chief action of the wheel being at the very extremities of the vibrations, and being very abrupt, the variations in its force are most hurtful to the isochronism of the vibrations.

Although this scapement is extremely simple, it is susceptible of more degrees of goodness or imperfection than almost any other, by the variation of the few particulars of its construction. We shall therefore briefly describe that construction which long experience has sanctioned as approaching near to the best performance that can be obtained from the common scapement. Fig. 11. represents it in what are thought its best proportions, as it appears when looking straight down on the end of the balance arbor. C is the centre of the balance and verge. CA and CB are the two pallets; CA being the upper pallet, or the one next to the balance, and CB being the lower one. F and D are two teeth of the crown wheel, moving from left to right; and E, G, are two teeth on the lower part of the circumference, moving from right to left. The tooth D is represented as just escaped from the point of CA, and the lower tooth E as just come in contact with the lower pallet. The scapement should not, however, be quite so close, because an inequality on the teeth might prevent D from escaping at all. For if E touch the pallet CB before D has quitted CA, all will stand still. This fault will be corrected by withdrawing the wheel a little from the verge, or by shortening the pallets.

The proportions are as follow. The distance between the front of the teeth (that is, of G, F, E, D) and the axis C of the balance is one-fifth of FA, the distance between the points of the teeth. The length CA, CB of the pallets is three-fifths of the same distance. The pallets make an angle ACB of 95 degrees, and the front DH or FK of the teeth make an angle of 25° with the axis of the crown-wheel. The sloping side of the tooth must be of an epicycloidal form, suited to the relative motion of the tooth and pallet.

From these proportions it appears that the pallet A can *throw out*, by the action of the tooth D, till it reaches *a*, 120 degrees from CL, the line of the crown-wheel axis For it can throw out till the pallet B strike against the front of E, which is inclined 25° to CL. To this add BCA, = 95°, and we have LC*a* = 120. In like manner B will throw out as far on the other side. From 240°, the sum of these angles, take the angle of the pallets 95°, and there remains 145° for the greatest vibration which the balance can make without striking the front of the teeth. This extent of vibration supposes the teeth to terminate in points, and the acting surfaces of the pallets to be planes directed to the very axis of the verge. But the points of the teeth must be rounded off a little for strength, and to diminish friction on the face of the pallets. This diminishes the angle of scapement very considerably, by shortening the teeth. Moreover, we must by no means allow the point of the pallet to bank or strike on the foreside of a tooth. This would greatly derange the vibration by the violence and abruptness of the check which the wheel would give to the pallet. This circumstance makes it improper to continue the vibrations much beyond the angle of scapement. One-third of a circle, or 120°, is therefore reckoned a very proper vibration for a scapement made in these proportions. The impulse of the wheels, or the angle of scapement, may be increased by making the face of the pallets a little concave (preserving the same angle at the centre). The vibration may also be widened by pushing the wheel nearer to the verge. This would also diminish the recoil. Indeed this may be entirely removed by bringing the front of the wheel up to C, and making the face of the pallet not a radius, but parallel to a radius and behind it, *i. e.* by placing the pallet CA so that its acting face may be where its back is just now. In this case, the tooth D would drop on it at the centre, and lie there at rest, while the balance completes its vibration. But this would make the banking (as the stroke is called) on the teeth almost unavoidable. In short, after varying every circumstance in every possible manner, the best makers have settled on a scapement very nearly such as we have described. Precise rules can scarcely be given; because the law by which the force acting on the pallets varies in its intensity, deviates so widely from the action of the balance spring, especially near the limits of the excursions."

The discoveries of Huyghens and Newton in rational mechanics engaged all the mathematical philosophers of Europe in the solution of mechanical problems, about the end of the last century. The vibrations of elastic plates or wires, and their influence on watch balances, became familiar to every body. The great requisites for producing isochronous vibrations were well understood; and the artists were prompted by the speculatists to attempt constructions of scapements proper for this purpose. It appeared clearly, that the most effectual means for

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for this purpose was to leave the balance unconnected with the wheels, especially near the extremities of the vibration, where the motion is languid, and where every inequality of maintaining power must act for a longer time, and therefore have a great effect on the whole duration of the vibrations. The maxim of construction that naturally arises from these reflections is to *confine*, if possible, *the action of the wheels to the middle of the vibration*, where the motion is rapid, and where the chief effect of an increase or diminution of the maintaining power will be to enlarge or contract the angular motions, but will make little change on their duration; because the greatest part of the motion will be effected by the balance spring alone. This maxim was inculcated in express terms by John Bernoulli, in his *Recherches Mechaniques et Physiques*; but it had been suggested by common sense to several unlettered artists before that time. About the beginning of this century watches were made in London, where the verge had a portion *e d b* (fig. 12.) of a small cylinder, having its centre *c* in the axis, and a radial pallet *b a* proceeding from it. Suppose a tooth just escaped from the point of the pallet, moving in the direction *b d e*, the cylindrical part was so situated that the next tooth dropped on it at a small distance from its termination. While the verge continues turning in the direction *b d e*, the tooth continues resting on the cylinder, and the balance sustains no *action* from the wheels, and has only to overcome the minute frictions on the polished surface of a hard steel cylinder. This motion may perhaps continue till the pallet acquires the position *f*, almost touching the tooth. It then stops, its motion being extinguished by the increasing force of the spring. It now returns, moving in the direction *e d b*; and when the pallet has acquired the position *c i*, the tooth *g* quits the circumference of the cylinder, and drops in on the pallet at the very centre. The crooked form of the tooth allows the pallet to proceed still farther, before there is any danger of banking on the tooth. This vibration being also ended, the balance resumes its first direction, and the tooth now acts on the face of the pallet, and restores to the balance all the motion which it had lost by friction, &c. during the two preceding vibrations.

It is evident that this construction obviates all the objections to the former recoiling scapement, and that, by sufficiently diminishing the diameter of the cylindrical part, the friction may be reduced to a very small quantity, and the balance be made to move by the action of the spring during the whole of the excursion, and of the returning vibration. Yet this construction does not seem to have come much into use, owing, in all probability, to the great difficulty of making the drop so accurate in all the teeth. The smallest inequality in the length of a tooth would occasion it to drop sooner or later; and if the cylinder was made very small, to diminish friction, the formation of the notch was almost a microscopical operation, and the smallest shake in the axis of the verge or the balance-wheel would make the tooth slip past the cylinder, and the watch run down amain.

About the same time, a French artist in London (then the school of this art) formed another scapement, with the same views. We have not any distinct account of it, but are only informed (in the 7th volume of the *Machines approuvées par l'Acad. des Sciences*) that the tooth rested on the surface of a hollow cylinder, and then escaped by acting on the inclined edge of it. But we may presume that it had merit, being there told that Sir Isaac Newton wore a watch of this kind.

A much superior scapement, on the same principle, was invented by Mr Geo. Graham, at the same time that he changed the recoiling scapement for pendulums into the dead beat. Indeed it is the same scapement, accommodated to the large vibrations of a balance. In fig. 13. DE represents part of the rim of the balance-wheel. A and C are two of its teeth, having their faces *b e* formed into planes, inclined to the circumference of the wheel, in an angle of about 15 degrees; so that the length *b e* of the face is nearly quadruple of its height *e m*. Suppose a circular arch ABC described round the centre of the wheel, and through the middle of the faces of the teeth. The axis of the balance passes thro' some point B of this arch, and we may say that the mean circumference of the teeth passes through the centre of the verge. On this axis is fixed a portion of a thin hollow cylinder *b c d*, made of hard tempered steel, or of some hard and tough stone, such as ruby or sapphire. Agates, though very hard, are brittle. Chalcedony and cornelian are tough, but inferior in hardness. This cylinder is so placed on the verge, that when the balance is in its quiescent position, the two edges *b* and *d* are in the circumference which passes through the points of the teeth. By this construction the portion of the cylinder will occupy 210° of the circumference, or 30° more than a semicircle. The edge *b*, to which the tooth approaches from without, is rounded off on both angles. The other edge *d* is formed into a plane, inclined to the radius about 30°.

Now, suppose the wheel pressed forward in the direction AC. The point *b* of the tooth, touching the rounded edge, will push it outwards, turning the balance round in the direction *b c d*. The heel *e* of the tooth will escape from this edge when it is in the position *h*, and *e* is in the position *f*. The point *b* of the tooth is now at *d*, but the edge of the cylinder has now got to *i*. The tooth, therefore, rests on the inside of the cylinder, while the balance continues its vibration a little way, in consequence of the shove which it has received from the action of the inclined plane pushing it out of the way, as the mould board of a plough shoves a stone aside. When this vibration is ended, by the opposition of the balance-spring, the balance returns, the tooth (now in the position B) rubbing all the while on the inside of the cylinder. The balance comes back into its natural position *b c d*, with an accelerated motion, by the action of its spring, and would, of itself, vibrate as far, at least, on the other side. But it is aided again by the tooth, which, pressing on the edge *d*, pushes it aside, till it come into the position *k*, when the tooth escapes from the cylinder altogether. At this moment the other edge of the cylinder is in the position *l*, and therefore is in the way of the next tooth, now in the position A. The balance continues its vibration, the tooth all the while resting, and rubbing on the outside of the cylinder. When this vibration, in the direction *d c b*, is finished, the balance resumes its first motion *bcd*, by the action of the spring, and the tooth begins to act on the first edge *b*, as soon as the balance gets into its natural position, shoves it aside, escapes from it, and drops on the inside of the cylinder. In this manner are

the

the vibrations produced, gradually increased to their maximum, and maintained in that state. Every succeeding tooth of the wheel acts first on the edge b, and then on the edge d; resting first on the outside, and then on the inside of the cylinder. The balance is under the influence of the wheels while the edge b passes to h, and while d passes to k; and the rest of the vibration is performed without any *action* on the part of the wheels, but is a little obstructed by friction, and by the clamminess of the oil. In the construction now described, the arch of action or scapement is evidently 30°, being twice the angle which the face of a tooth makes with the circumference.

The reader will perceive, that when this scapement is executed in such a manner that the succeeding tooth in contact with the cylinder at the instant that the preceding one escapes from it, the face of the tooth must be equal to the inside diameter of the cylinder, and that the distance between the heel of one tooth and the point of the following one must be equal to the outside diameter. When the scapement is so close there is no drop. A good artist approaches as near to this adjustment as possible; because, while a tooth is dropping, but not yet in contact, it is not acting on the balance, and some force is lost. The execution is accounted very good, if the distance between the centres of two teeth is twice the external diameter of the cylinder. This allows a drop equal to the thickness of the cylinder, which is about $\frac{1}{10}$th of its diameter.

We must also explain how this cylinder is so connected with the verge as to make such a great revolution round the tooth of the wheel. The triangular tooth $e\,b\,m$ is placed on the top of a little pillar or pin fixed into the extremity of the piece of brass m D formed on the rim of the wheel. Thus the wedge-tooth has its plane parallel to the plane of the wheel, but at a small distance above it. Fig. B represents the verge, a long hollow cylinder of hard steel. A great portion of the metal is cut out. If it were spread out flat, it would have the shape of fig. C. Suppose this rolled up till the edges GH and G′H′ are joined, and we have the exact form. The part acted on by the point of the tooth is the dotted line $b\,d$. The part DIFE′ serves to connect the two ends. Thus it appears to be a very slender and delicate piece; but being of tempered steel, it is strong enough to resist moderate jolts. The ruby cylinders are much more delicate.

Such is the cylinder scapement of Mr Graham, called also the HORIZONTAL SCAPEMENT, because the balance wheel is parallel to the others. Let us see how far it may be expected to answer the intended purposes. If the excursions of the balance beyond the angle of impulsion were made altogether unconnected with the wheels, the *whole vibration* would be quicker than one of the same extent, made by the action of the balance-spring alone, because the middle part of it is accelerated by the wheels. But the excursions are obstructed by friction and the clamminess of oil. The effect of this in *obstructing* the motion is very considerable. Mr Le Roy placed the balance so, that it rested when the point of the tooth was on the middle of the cylindric surface. When the wheel was allowed to press on it, and it was drawn 80° from this position, it vibrated only during 4½ seconds. When the wheel was not allowed to touch the cylinder, it vibrated 90 seconds, or 20 times as long; so much did the friction on the cylinder exceed that of the pivots. We are not sufficiently acquainted with the laws of either of these obstructions to pronounce decidedly whether they will increase or diminish the *time* of the whole vibrations. We observe distinctly, in motions with considerable friction, that it does not increase nearly so fast as the velocity of the motion; nay, it is often less when the velocity is very great. In all cases it is observed to terminate motions abruptly. The friction requires a certain force to overcome it, and if the body has any less it will stop. Now this will not only contract the excursion of the balance, but will shorten the time. But the return to the angle of impulsion will undoubtedly be of longer duration than the excursion; for the arch of return, from the extremity of the excursion to its beginning, where the angle of impulsion ends, is the same with the arch of excursion. The velocity which the balance has in any point of the return is less than what it had in the same point of the excursion; because, in the excursion, it had velocity enough to carry it to the extremity, and also to overcome the friction. In the return, it could, even without friction, only have the velocity which would have carried it to the extremity; and this smaller velocity is diminished by friction during the return. The velocity being less through the whole return than during the excursion, the time must be greater. It may therefore happen that this retardation of the return may compensate the contraction of the excursion and the diminution of its duration. In this case the vibration will occupy the same time as if the balance had been free from the wheels. But it may more than compensate, and the vibrations will then be slower; or it may not fully compensate, and they will be quicker. We cannot therefore say, *à priori*, which of the two will happen: but we may venture to say that an increase of the force of the wheels will make the watch go slower: for this will exert a greater pressure, give a greater impulsion, produce a wider excursion, and increase the friction during that greater excursion, making the wide vibrations slower than the narrow ones; because the angle of impulsion remaining the same, the pressures exerted must be quadrupled, in order to double the excursion (see DYNAMICS, n° 95. *Suppl.*), and therefore the friction will be increased in a greater proportion than the momentum which is to overcome it. But, with respect to the obstruction arising from the viscidity of the oil, we know that it follows a very different law. It bears a manifest relation to the velocity, and is nearly proportional to it. But still it is difficult to say how this will affect the whole vibration. The duration of the excursion will not be so much contracted as by an equal obstruction from friction, because it will not terminate the motion abruptly. There are therefore more chances of the increased duration of the return exceeding the diminution of it in the excursion. All that we can say, therefore, is, that there will be a compensation in both cases. The time of excursion will be contracted, and that of return augmented.

Now, as the friction may be greatly diminished by fine polish, fine oil, and a small diameter of the cylinder, we may reasonably expect that the vibrations of such a balance will not vary nearly so much from isochronism as with a recoiling scapement, and will be little affected by changes in the force of the wheels.

Watch-work.

Accord-

Accordingly, Graham's cylindrical ſcapement ſupplanted all others as ſoon as it was generally known. We cannot compare the vibrations with thoſe of a free balance, becauſe we have no way of making a free balance vibrate for ſome hours. But we find that doubling or trebling the force of the wheels makes very little alteration in the rate of the watch, though it greatly enlarges the angular motion. Any one may perceive the immenſe ſuperiority of this ſcapement over the common recoiling ſcapement, by preſſing forward the movement of a horizontal watch with the key, or by keeping it back. No great change can be obſerved in the frequency of the beats, however hard we preſs. But a more careful examination ſhews that an increaſe of the power of the wheels generally cauſes the watch to go ſlower; and that this is more remarkable as the watch has been long going without being cleaned. This ſhews that the cauſe is to be aſcribed to the friction and oil operating on the wide arches of excurſion. But when this ſcapement is well executed, in the beſt proportions of the parts, the performance is extremely good. We know ſuch watches, which have continued for ſeveral weeks without ever varying more than 7″ in one day from equable motion. We have ſeen one whoſe cylinder was not concentric with the balance, but ſo placed on the verge that the axis of the verge was at o (fig. 13.), between the centre B of the cylinder and the entering edge b, and Bc was equal to the thickneſs of the cylinder. The watch was made by Emery of London, and was ſaid to go with aſtoniſhing regularity, ſo as to equal any time-piece while the temperature of the air did not vary; and when clean, was ſaid to be leſs affected by the temperature than a watch with a free ſcapement, but unprovided with a compenſation piece. It is evident that this watch muſt have a minute recoil. This was ſaid to be the aim of the artiſt, in order to compenſate for the obſtruction cauſed by friction during the return of the balance from its excurſions. It indeed promiſes to have this effect; but we ſhould fear that it ſubjects the excurſions to the influence of the wheels. We ſuſpect that the indifferent performance of cylinder watches may often ariſe from the cylinder being off the centre in ſome diſadvantageous manner.

The watch from which the proportions here ſtated were taken, is a very fine one made by Graham for Archibald Duke of Argyle, which has kept time with the regularity now mentioned. We believe that there are but few watches which have ſo large a portion of the cylinder: few indeed have more than one half, or 180° of the circumference. But this is too little. The tooth of the wheel does not begin to act on the reſting cylinder till its middle point A or B touch one of the edges. To obtain the ſame angle of ſcapement, the inclination of the face of the tooth muſt be increaſed (it muſt be doubled); and this requires the maintaining power to be increaſed in the ſame proportion. Beſides, in ſuch a ſcapement it may happen that the tooth will never reſt on the cylinder; becauſe the inſtant that it quits one edge it falls on the other, and puſhes it aſide, ſo that the balance acquires no wider vibration than the angle of ſcapement, and is continually under the influence of the wheels. The ſcapement is in its beſt ſtate when the portion of the cylinder exceeds 180° by twice the inclination of the teeth to the circumference of the wheel.

It would employ volumes to deſcribe all the ſcapements which have been contrived by different artiſts, aiming at the ſame points which Graham had in view. We ſhall only take notice of ſuch as have ſome eſſential difference in principle.

Fig. 14. repreſents a ſcapement invented in France, and called the *Echappement à Virgule*, becauſe the pallet reſembles a comma. The teeth A, B, C, of the balance wheel are ſet very oblique to the radius, and there is formed on the point of each a pin, ſtanding up perpendicular to the plane of the wheel. This greatly reſembles the wheel of Graham's ſcapement, when the triangular wedge is cut off from the top of the pin on which it ſtands. The axis c of the verge is placed in the circumference paſſing through the pins. The pallet is a plate of hard ſteel $a\,e\,f\,d\,b$, having its plane parallel to the plane of the wheel. The inner edge of this plate is formed into a concave cylindrical ſurface between o and b, whoſe axis c coincides with the axis of the verge. Adjoining to this is the acting face $b\,d$ of the pallet. This is either a ſtraight line $b\,d$, making an angle of nearly 30° with a line $c\,b\,g$ drawn from the centre, or it is more generally curved, according to the noſtrum of the artiſt. The back of the pallet $a\,e\,f$ is alſo a cylindrical ſurface (convex) concentric with the other. This extends about 100° from a to f. The part between f and d may have any ſhape. The interval $a\,o$ is formed into a convex ſurface, in ſuch a manner as to be everywhere interſected by the radius in an angle of 30° nearly; *i. e.* it is a portion of an equiangular ſpiral. The whole of this is connected with the verge by a crank, which paſſes perpendicularly through it between f and e; and the plate is ſet at ſuch height on the crank or verge, that it can turn round clear of the wheel, but not clear of the pins. The teeth of the wheel are ſet ſo obliquely, and made ſo ſlender, that the verge may turn almoſt quite round without the crank's banking on the teeth. The part $f\,d\,b$, called the horn, is of ſuch a length, that when one pin B reſts on the outſide cylinder at a, the point d is juſt clear of the next pin A.

When the wheel is not acting, and the balance ſpring is in equilibrio, the poſition of the balance is ſuch that the point d of the horn is near i, about 30° from d. The figure repreſents it in the poſition which it has when the tooth A has juſt eſcaped from the point d of the horn. In this poſition the next tooth B is applied to the convex cylinder, a very little way (about 5°) from its extremity a. This deſcription will enable the reader to underſtand the operation of the virgule ſcapement.

Now ſuppoſe the pin A juſt eſcaped from the horn. The ſucceeding pin B is now in contact with the back of the cylinder; and the balance, having got an impulſe by the action of A along the concave pallet $b\,d$, continues its motion in the direction $d\,g\,h$, till its force is ſpent, the point of the horn arriving perhaps at h, more than 90° from d. All this while the following tooth B is reſting on the back $e\,f$ of the cylinder. The balance now returns, by the action of its ſpring; and when the horn is at i, the pin gets over the edge $a\,o$, and drops on the oppoſite ſide of the concave cylinder, where it reſts, while the horn moves from i to k, where it ſtops, the force of the balance being again ſpent. The balance then returns; and when the horn comes within

30° of *d*, the pin gets out of the hollow cylinder, shoves the horn out of its way, and escapes at *d*. Besides the impulse which the balance receives by the action of the wheel on the horn *b d*, there is another, though smaller, action in the contrary direction, while the point of B passes over the surface *a o*; for this surface being inclined to the radius, the pressure on it urges the balance round in the direction *b d i*.

The chief difference of this scapement from the former is that the inclined plane is taken from the teeth of the wheel, and placed on the verge. This alone is a considerable improvement; for it is difficult to shape all the teeth alike; whereas the horn *b d* is invariable. Moreover, the resting parts, although they be drawn large in this figure for the sake of distinctness, may be made vastly smaller than Graham's cylinder, which must be big enough to hold a tooth within it. By this change, the friction, during the repose of the wheel, that is, during the excursions of the balance, may be vastly diminished. The inside cylinder need be no bigger than to receive the pin. But although the performance of these scapements is excellent, they have not come into general use in this country. The cause seems to be the great nicety requisite in making the pins of the wheel pass exactly through the axis of the verge. The least shake in the pivots of the balance and balance-wheel must greatly change the action. A very minute increase of distance between the pivots will cause the pin B to slide from the edge *a* to the horn, without resting at all on the inside cylinder; and when it does so, it will stop the balance at once, and, immediately after, the watch will run down. The same irregularities will happen if all the pins be not at precisely the same distance from the axis of the wheel.

This scapement was greatly improved, and, in appearance, totally changed, by Mr Lepaute of Paris in 1753. By placing the pins alternately on the two sides of the rim of the balance-wheel, he avoided the use of the outside cylinder altogether. The scapement is of such a singular form, that it is not easy to represent it by any drawing. We shall endeavour, however, to describe it in such a manner as that our readers, who are not artists, will understand its manner of acting. Artists by profession will easily comprehend how the parts may be united which we represent as separate.

Let ABC (fig. 15.) represent part of the rim of the balance-wheel, having the pins 1, 2, 3, 4, 5, &c. projecting from its faces; the pins 1, 3, 5, being on the side next the eye, but the pins 2 and 4 on the farther side. D is the centre of the balance and verge, and the small circle round D represents its thickness. But the verge in this place is crooked, like a crank, that the rim of the wheel may not be interrupted by it. This will be more particularly described by and bye. There is attached to it a piece of hard tempered steel *a b c d*, of which the part *a b c* is a concave arch of a circle, having D for its centre. It wants about 30° of a semicircle. The rest of it *c d* is also an arch of a circle, having the same radius with the balance-wheel. The natural position of the balance is such, that a line drawn from D, through the middle of the face *c d*, is a tangent to the circumference of the wheel. But, suppose the balance turned round till the point *d* of the horn comes to *d'*, and the point *c* comes to 2, in the circumference in which the pins are placed. Then the pin, pressing on the beginning of the horn or pallet, pushes it aside, slides along it, and escapes at *d*, after having generated a certain velocity in the balance. So far this scapement is like the virgule scapement described already. But now let another pallet, similar to the one now described, be placed on the other side of the wheel, but in a contrary position, with the acting face of the pallet turned away from the centre of the wheel. Let it be so placed at E, that the moment that the pin 1, on the upper side of the wheel, escapes from the pallet *c d*, the pin 4, on the under side of the wheel, falls on the end of the circular arch *e f g* of the other pallet. Let the two pallets be connected by means of equal pulleys G and F on the axis of each, and a thread round both, so that they shall turn one way. The balance on the axis D, having gotten an impulse from the action of the pin 1, will continue its motion from A towards *i*, and will carry the other pallet with a similar motion round the centre E from *b* towards *k*. The pin 4 will therefore rest on the concave arch *g f e* as the pallet turns round. When the force of the balance is spent, the pallet *c d* returns towards its first position. The pallet *g b* turns along with it; and when the point of the first has arrived at *d*, the beginning *g* of the other arrives at the pin 4; and, proceeding a little farther, this pin escapes from the concave arch *e f g*, and slides along the pallet *g b*, pushing it aside, and therefore urging the pallet round the centre E, and consequently (by means of the connection of the pulleys) urging the balance on the axis D round at the same time, and in the same direction. The pin 4 escapes from the pallet *g b*, when *b* arrives at 3; but in the time that the pin 4 was sliding along the yielding pallet *g b*, the pin 3 is moving in the circumference BDA; and the instant that the pin 4 escapes from *b* at 3, the pin 3 arrives at 2, and finds the beginning *c* of the concave arch *c b a* ready to receive it. It therefore rests on this arch, while the balance continues its motion. This perhaps continues till the point *b* of the arch comes to 2. The balance now stops, its force being spent, and then returns; and the pin 3 escapes from the circle at *c*, slides along the yielding pallet *c d*, and when it escapes at 1, another pin on the under side of the wheel arrives at 4, and finds the arch *g f e* ready to receive it. And in this manner will the vibration of the balance be continued.

This description of the mode of action at the same time points out the dimensions which must be given to the parts of the pallet. The length of the pallet *c d* or *g b* must be equal to the interval between two succeeding pins, and the distance of the centres D and E must be double of this. The radius D *e* or E *g* may be as small as we please. The concave arches *c b a* and *g f e* must be continued far enough to keep a pin resting on them during the whole excursion of the balance. The angle of scapement, in which the balance is under the influence of the wheels, is had by drawing D *c* and D *d*. This angle *c* D *d* is about 30°, but may be made greater or less.

Fig. B will give some notion how the two pallets may be combined on one verge. KL represents the verge with a pivot at each end. It is bent into a crank MNO, to admit the balance wheel between its branches. BC represents this wheel, seen edgewise, with its pins, alternately on different sides. The pallets are also represented

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preſented edgewiſe by $b\,c\,d$ and $b\,g\,f$, fixed to the inſide of the branches of the crank, fronting each other. The poſition of their acting faces may be ſeen in the preceding figure, on the verge D, where the pallet $g\,b$ is repreſented by the dotted line $2\,i$, as being ſituated behind the pallet $c\,d$. The remote pallet $2\,i$ is placed ſo, that when the point d of the near pallet is juſt quitted by a pin 1 on the upper ſide of the wheel, the angle formed by the face and the arch of reſt of the other pallet is juſt ready to receive the next pin 2, which lies on the under ſide of the rim. A little attention will make it plain, that the action will be preciſely the ſame as when the pallets were on ſeparate axes. The pin 1 eſcapes from d, and the pin 2 is received on the arch of reſt, and locks the wheel while the balance is continuing its motion. When it returns, 2 gets off the arch of reſt, puſhes aſide the pallet $2\,i$, eſcapes from it when i gets to 1, and then the pin 3 finds the point c ready to receive it, &c. The vibrations may be increaſed by giving a ſufficient impulſe through the angle of ſcapement. But they cannot be more than a certain quantity, otherwiſe the top N of the crank will ſtrike the rim of the wheel. By placing the pins at the very edge of the wheel, the vibrations may eaſily be increaſed to a ſemicircle. By placing them at the points of long teeth, the crank may get in between them, and the vibrations extended ſtill farther, perhaps to 240°.

This ſcapement is unqueſtionably a very good one; and when equally well executed, ſhould excel Graham's, both by having but two acting faces to form (and theſe of hard ſteel or of ſtone), and by allowing us to make the circle of reſt exceedingly ſmall without diminiſhing the acting face of the pallet. This will greatly diminiſh the friction and the influence of oil. But, on the other hand, we apprehend that it is of very difficult execution. The figure of the pallets, in a manner that ſhall be ſuſceptible of adjuſtment and removal for repair, and yet ſufficiently accurate and ſteady, ſeems to us a very delicate job.

Mr Cumming, in his Elements of Clock and Watch-work, deſcribes (ſlightly) pallets of the very ſame conſtruction, making what he conceives to be conſiderable improvements in the form of the acting faces and the curves of reſt. He has alſo made ſome watches with this ſcapement; but they were ſo difficult, that few workmen can be found fit for the taſk; and they are exceedingly delicate, and apt to be put out of order. The connection of the pallets with each other, and with the verge, makes the whole ſuch a contorted figure, that it is eaſily bent and twiſted by any jolt or unſkilful handling.

There remains another ſcapement of this kind, having the tooth of the balance-wheel reſting on a cylindrical ſurface on the axis of the verge during the excurſions of the balance beyond the angle of ſcapement, and which differs ſomewhat in the application of the maintaining power from all thoſe already deſcribed.

This is known by the name of *Dupleix's ſcapement*, and is as follows: Fig 16. repreſents the eſſential parts greatly magnified. AD is a portion of the balance-wheel, having teeth f, b, g, at the circumference. Theſe teeth are entirely for producing the *reſt* of the wheel, while the balance is making excurſions beyond the ſcapement. This is effected by means of an agate cylinder $o\,p\,q$, on the verge. This cylinder has a notch o. When the cylinder turns round in the direction $o\,p\,q$, the notch eaſily paſſes the tooth B which is reſting on the cylindric ſurface; but when it returns in the direction $q\,p\,o$, the tooth B gets into the notch, and follows it, preſſing on one ſide of it till the notch comes into the poſition o. The tooth, being then in the poſition b, eſcapes from the notch, and another tooth drops on the convex ſurface of the cylinder at B.

The balance-wheel is alſo furniſhed with a ſet of ſtout flat-ſided pins, ſtanding upright on its rim, as repreſented by a, D. There is alſo fixed on the verge a larger cylinder GFC above the ſmaller one $o\,p\,q$, with its under ſurface clear of the wheel, and having a pallet C, of ruby or ſapphire, firmly indented into it, and projecting ſo far as juſt to keep clear of the pins on the wheel. The poſition of this cylinder, with reſpect to the ſmaller one below it, is ſuch that, when the tooth b is eſcaped from the notch, the pallet C has juſt paſſed the pin a, which was at A while B reſted on the ſmall cylinder; but it moved from A to a, while B moved to b. The wheel being now at liberty, the pin a exerts its preſſure on the pallet C in the moſt direct and advantageous manner, and gives it a ſtrong impulſion, following and accelerating it till another tooth ſtops on the little cylinder. The angle of ſcapement depends partly on the projection of the pallet, and partly on the diameter of the ſmall cylinder and the advance of the tooth B into the notch. Independent of the action on the ſmall cylinder, the angle of ſcapement would be the whole arch of the large cylinder between C and x. But a ſtops before it is clear of the pallet, and the arch of impulſion is ſhortened by all the ſpace that is deſcribed by the pin while a tooth moves from B to b. It ſtops at a'.

We are informed by the beſt artiſts, that this ſcapement gives great ſatisfaction, and equals, if it do not excel, Graham's cylindrical ſcapement. It is eaſier made, and requires very little oil on the ſmall cylinder, and none at all on the pallet. They ſay that it is the beſt for pocket watches, and is coming every day more into repute. Theory ſeems to accord with this character. The reſting cylinder may be made very ſmall, and the direct impulſe on the pallet gives it a great ſuperiority over all thoſe already deſcribed, where the action on the pallet is oblique, and therefore much force is loſt by the influence of oil. But we fear that much force is loſt by the tooth B ſhifting its place, and thus ſhortening the arch of impulſion; for we cannot reckon much on the action of B on the ſide of the notch, becauſe the lever is ſo extremely ſhort. Accordingly, all the watches which we have ſeen of this kind have a very ſtrong main ſpring in proportion to the ſize and vibration of the balance. If we leſſen this diminution of the angle of impulſion, by leſſening the cylinder $o\,p\,q$, and by not allowing B to penetrate far into the notch, the ſmalleſt inequality of the teeth, or ſhake in the pivots of the balance or wheel, will cauſe irregularity, and even uncertainties in the locking and unlocking the wheel by this cylinder.

A ſcapement exceedingly like this was applied long ago by Dutertre, a French artiſt, to a pendulum. The only difference is, that in the pendulum ſcapement the ſmall cylinder is cut through to the centre, half of it only being left; but the pendulum ſcapement gives a more effective employment of the maintaining power, becauſe the

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the wheel acts on the pallet during the *whole* of the assisted vibration. In a balance scapement, if we attempt to diminish the inefficient motion of the pin from A to *a*, by lessening the diameter of the small cylinder, the hold given to the tooth in the notch will be so trifling, that the tooth will be thrown out by the smallest play in the pivot holes, or inequality in the length of the teeth.

With this we conclude our account of scapements, where the action of the maintaining power on the balance is suspended during the excursion beyond the angle of impulsion, by making a tooth rest on the surface of a small concentric cylinder. In such scapements, the balance, during its excursions, is almost free from any connection with the wheels, and its isochronism is disturbed by nothing but the friction on this surface.—We come now to scapements of more artful construction, in which the balance is really and completely free during the whole of its excursion, being altogether disengaged from the wheelwork. These are called DETACHED SCAPEMENTS. They are of more recent date. We believe that Mr Le Roi was the first inventor of them, about the year 1748. In the Memoirs of the Academy of Paris for that year, and in the Collection of approved Machines and Inventions, we have descriptions of the contrivance. The balance-wheel rests on a detent, while the balance *is* vibrating in perfect freedom. It has a pallet standing out from the centre, which, in the course of vibration, passes close by the point of a tooth of the wheel. At that instant a pin, connected with this pallet, withdraws the detent from the wheel, and the tooth just now mentioned follows the pallet with rapidity, and gives it a smart push forward. Immediately after, another tooth of the wheel meets the other claw of the detent, and the wheel is again locked. When the balance returns, the pin pushes the detent back into its former place, where it again locks the wheel. Then the balance, resuming its first direction, unlocks the wheel, and receives another impulsion from it. Thus the balance is unconnected with the wheels, except while it gets the impulsion, and at the moments of unlocking the wheels.

This contrivance has been reduced to the greatest possible simplicity by the British artists, and seems scarcely capable of farther improvement. The following is one of the most approved constructions. In fig. 17. *a b c* represents the pallet, which is a cylinder of hard steel or stone, having a notch *a b*. A portion of the balance-wheel is represented by AB. It is placed so near to the cylinder that the cylinder is no more than clear of *two adjoining* teeth. DE is a long spring, so fixed to the watch-plate at E, as to press very gently on the stop pin G. A small stud F is fixed to that side of the spring that is next to the wheel. The tooth of the wheel rests on this stud, in such a manner that the tooth *a* is just about to touch the cylinder, and the tooth *f* is just clear of it. Another spring, extremely slender, is attached to the spring DE, on the side next the balance wheel, and claps close to it, but keeping clear of the stud F, and having its point *o* projecting about $\frac{1}{15}$th of an inch beyond its extremity. When the point *o* is pressed towards the wheel, it yields most readily; but, when pressed in the opposite direction, it carries the spring DE along with it. The cylinder being so placed on the verge that the edge *a* of the notch is close by the tooth *a*, a hole is drilled at *i*, close by the projecting point of the slender spring, and a small pin is driven into this hole. This is the whole apparatus; and this situation of the parts corresponds to the quiescent position of the balance.

Now, let the balance be turned out of this position 80 or 90 degrees, in the direction *a b c*. When it is let go, it returns to this position with an accelerated motion. The pin *i* strikes on the projecting point of the slender spring, and, pressing the strong spring DE outward from the wheel, withdraws the stud F from the tooth; and thus unlocks the wheel. The tooth *a* engages in the notch, and urges round the balance. The pin *i* quits the slender spring before the tooth quits the notch; so that when it is clear of the pallet, the wheel is locked again on the stud F, and another tooth *g* is now in the place of *a*, ready to act in the same manner. When the force of the balance is spent, it stops, and then returns toward its quiescent position with a motion continually accelerated. The pin *i* arrives at the point *o* of the slender spring, raises it from the strong spring without disturbing the latter, and almost without *being* disturbed by this trifling obstacle; and it goes on, turning in the direction *a b c*, till its force is again spent; it stops, returns, again unlocks the wheel, and gets a new impulsion. And in this manner the vibrations are continued. Thus we see a vibration, almost free, maintained in a manner even more simple than the common crutch scapement. The impulse is given direct, without any decomposition by oblique action, and it is continued through the *whole* motion of the wheel. No part of this motion is lost, as in Dupleix's scapement, by the *gradual* approach of the tooth to its active position. Very little force is required for unlocking the wheel, because the spring DFE is made slender at the remote end E, so that it turns round E almost like a lever turning on pivots. A sudden twitch of the watch, in the direction *b a*, might chance to unlock the wheel. But this will only derange one vibration, and even that not considerably, because the teeth are so close to the cylinder that the wheel cannot advance till the notch comes round to the place of scapement. A tooth will continue pressing on the cylinder, and by its friction will change a little the extent and duration of a single vibration. The greatest derangement will happen if the wheel should thus unlock by a jolt, while the notch passes through the arch of scapement in the returning vibration. Even this will not greatly derange it, when the watch is clean and vibrating wide; because, in this position, the balance has its greatest momentum, and the direction of the only jolt that can unlock the wheel tends to increase this momentum relatively. In short, considering it theoretically, it seems an almost perfect scapement; and the performance of many of these watches abundantly confirms that opinion. They are known to keep time for many days together, without varying one second from day to day; and this even under considerable variations of the maintaining power. Other detached scapements may equal this, but we scarcely expect any to exceed it; and its simplicity is so much superior to any that we have seen, that, on this account, we are disposed to give it the preference. We do not mean to say that it is the best for a pocket watch. Perhaps the scapement of Dupleix or Graham may be preferable, as being susceptible

ceptible of greater ftrength, and more able to withftand jolts. Yet it is a fact that fome of the watches made in this form by Arnold and others have kept time in the wonderful manner abovementioned while carried about in the pocket.

Mr Mudge of London invented, about the year 1763, another detached fcapement, of a ftill more ingenious conftruction. It is a counterpart of Mr Cumming's fcapement for pendulums. The contrivance is to this effect. In fig. 18. *a b c* reprefents the balance. Its axis is bent into a large crank EFGHIK, fufficiently roomy to admit within it two other axes M and L, with the proper cocks for receiving their pivots. The three axes form one ftraight line. About thefe fmaller axes are coiled two auxiliary fprings, in oppofite directions, having their outer extremities fixed in the ftuds A and B The balance has its fpring alfo, as ufual, and the three fprings are fo difpofed that each of them alone would keep the balance at reft in the fame pofition, which we may fuppofe to be that reprefented in the figure. The auxiliary fprings A and B are connected with the balance only occafionally, by means of the arms *m* and *n* projecting from their refpective axes. Thefe arms are catched on oppofite fides by the pins *o*, *p*, in the branches of the crank; fo that when the balance turns round, it carries one or other of thofe arms round with it, and, during this motion, it is affected by the auxiliary fpring connected with the arm fo carried round by it.

Let us fuppofe that the balance vibrates 120° on each fide of its quiefcent pofition *a b c*, fo that the radius E *a* acquires, alternately, the pofitions E *b* and E *c*. The auxiliary fprings are connected with the wheels by a common dead-beat pendulum fcapement, fo that each can be feparately wound up about 30°, and retained in that pofition. Let us alfo fuppofe that the fpring A has been wound up 30° in the direction *a b*, by the wheel-work, and that the point *a* of the rim of the balance, having come from *c*, is paffing through *a* with its greateft velocity. When the radius E *a* has paffed *a* 30° in its courfe toward *b*, the pin *o* finds the arm *m* in its way, and carries it along with it till *a* gets to *b*. But, by carrying away the arm *m*, it has unlocked the wheel-work, and the fpring B is now wound up 30° in the other direction, but has no connection with the balance during this operation. Thus the balance finifhes its femivibration *a b* of 120°, oppofed by its own fpring the whole way, and by the auxiliary fpring A through an angle of 90°. It returns to the pofition E *a*, aided by A and by the balance-fpring, through an angle of 120°. In like manner, when E *a* has moved 30° toward the pofition E *c*, the pin *p* meets with the arm *n*, and carries it along with it through an angle of 90°, oppofed by the fpring B, and then returns to the pofition E *a*, affifted by the fame fpring through an arch of 120°.

Thus it appears that the balance is oppofed by each auxiliary fpring through an angle of 90°, and affifted through an angle of 120°. This difference of action maintains the vibrations, and the neceffary winding up of the auxiliary fprings is performed by the wheel-work, at a time when they are totally difengaged from the balance. No irregularity of the wheel-work can have any influence on the force of the auxiliary fprings, and therefore the balance is completely difengaged from all thefe irregularities, except in the fhort moment of unlocking the wheel that winds up the fprings.

This is a moft ingenious conftruction, and the neareft approach to a free vibration that has yet been thought of. It deferves particular remark that, during the whole of the returning or accelerated femivibration, the united force of the fprings is proportional to the diftance from the quiefcent pofition. The fame may be faid of the retarded excurfion beyond the angle of impulfe: therefore the only deviation of the forces from the law of cycloidal vibration is during the motion from the quiefcent pofition to the meeting with the auxiliary fpring. Therefore, as the forces, on both fides, beyond this angle, are in their due proportion, and the balance always makes fuch excurfions, there feems nothing to difturb the ifochronifm, whether the vibrations are wide or narrow. Accordingly, the performance of this fcapement, under the fevereft trials, equalled any that were compared with it, in as far as it depended on fcapement alone. But it is evident that the execution of this fcapement, though moft fimple in principle, muft always be vaftly more difficult than the one defcribed before. There is fo little room, that the parts muft be exceedingly fmall, requiring the moft accurate workmanfhip. We think that it may be greatly fimplified, preferving all its advantages, and that the parts may be made of more than twice their prefent fize, with even lefs load on the balance from the inertia of matter. This improvement is now carrying into effect by a friend.

Still, however, we do not fee that this fcapement is, theoretically, fuperior to the laft. The irregularities of maintaining power affect that fcapement only in the arch of impulfion, where the velocity is great, and the time of action very fmall. Moreover, the chief effect of the irregularities is only to enlarge the excurfions; and in thefe the wheels have no concern.

Mr Mudge has alfo given another detached fcapement, which he recommends for pocket watches, and executed entirely to his fatisfaction in one made for the Queen. A dead beat pendulum fcapement is interpofed, as in the laft, between the wheels and the balance. The crutch EDF (fig. 19.) has a third arm DG, ftanding outwards from the meeting of the other two, and of twice their length. This arm terminates in a fork AGB. The verge V has a pallet C, which, when all is at reft, would ftand between the points A, B of the fork. But the wheel, by its action on the pallet E, forces the fork into the pofition B *g b*, the point A of the fork being now where B was before, juft touching the cylindrical furface of the verge. The fcapement of the crutch EDF is not accurately a dead beat fcapement, but has a very fmall recoil beyond the angle of impulfion. By this circumftance the branch A (now at B) is made to prefs moft gently on the cylinder, and keeps the wheel locked, while the balance is going round in the direction BHA. The point A gets moving from A to B by means of a notch in the cylinder, which turns round at the fame time by the action of the branch AG on the pallet C; but A does not touch the cylinder during this motion, the notch leaving free room for its paffage. When the balance returns from its excurfion, the pallet C ftrikes on the branch A (ftill at B), and unlocks the wheel. This now acting [illegible] he crutch

Watch-work.

crutch pallet F, causes the branch b of the fork to follow the pallet C and give it a strong impulse in the direction in which it is then moving, causing the balance to make a semivibration in the direction AHB. The fork is now in the situation A g a, similar to B g b, and the wheel is again locked on the crutch pallet E.

The intelligent reader will admit this to be a very steady and effective scapement. The lockage of the wheel is procured in a very ingenious manner; and the friction on the cylinder, necessary for effecting this, may be made as small as we please, notwithstanding a very strong action of the wheel: For the pressure of the fork on the cylinder depends entirely on the degree of recoil that is formed on the pallets E and F. *Pressur* on the cylinder is not *indispensably* necessary, and the crutch scapement might be a real dead beat. But a small recoil, by keeping the fork in contact with the cylinder, gives the most perfect steadiness to the motion. The ingenious inventor, a man of approved integrity and judgment, declares that her Majesty's watch was the best pocket watch he had ever seen. We are not disposed to question its excellency. We saw an experiment watch of this construction, made by a country artist, having a balance so heavy as to vibrate only twice in a second. Every vibration was sensibly beyond a turn and a half, or 540°. The artist assured us, that when its proper balance was in, vibrating somewhat more than five times in a second, the vibrations even exceeded this. He had procured it this great mobility by substituting a roller with fine pivots in place of the simple pallet of Mudge. This great extent of detached vibration is an unquestionable excellence, and is peculiar to those two scapements of this ingenious artist.

Very ingenious scapements have been made by Ernshaw, Howel, Hayley, and other British artists; and many by the artists of Paris and Geneva. But we must conclude the article, having described all that have any difference in principle.

The scapement having been brought to this degree of perfection, we have an opportunity of making experiments on the law of action of springs, which has been too readily assumed. We think it easy to demonstrate, that the figure of a spring, which must have a great extent of rapid motion, will have a considerable influence on the force which it impresses on a balance *in actual motion*. The accurate determination of this influence is not very difficult in some simple cases. It is the greatest of all in the plane spiral, and the least in the cylindrical; and, in this last form, it is so much less as the diameter is less, the length of the spring being the same. By employing many turns, in order to have the same ultimate force at the extremity of the excursion, this influence is increased. A particular length of spring, therefore, will make it equal to a given quantity; and it may thus compensate for a particular magnitude of friction, and other obstructions. This accounts for the observation of Le Roy, who found that every spring, *when applied to a movement*, had a certain length, which made the wide and narrow vibrations isochronous. His method of trial was so judicious, that there can be no doubt of the justness of his conclusion. His time-keeper had no fuzee; and when the last revolution of the main wheel was going on, the vibrations were but of half the extent of those made during the first revolution. Without minding the real rate of going, he only compared the duration of the first and last revolution of the minute hand. An artist of our acquaintance repeated these experiments, and with the same result: But, unfortunately, could derive little benefit from them; because in one state of the oil, or with one balance, he found the lengths of the same spring, which produced isochronous vibrations, were different from those which had this effect in another state of the oil, or with another balance. He also observed another difference in the rate, arising from a difference of position, according as XII, VI, III, or IX, was uppermost; which difference plainly arises from the swagging of the spring by its weight, and, in that state, acting as a pendulum. This unluckily put a stop to his attempts to lessen this hurtful influence by employing a cylindrical spiral of small diameter and great length.

WATER Blowing Machine, called in French *Soufflet d'eau* or *trompe*, is a machine which, by the action of falling water, supplies air to a blast furnace. It consists of an upright pipe, through which a shower of water is made to fall; and this shower carries down with it a mass of air, which is received beneath in a kind of tub, and conducted to the furnace by means of a pipe. The first idea of such a machine was doubtless suggested by those local winds, which are always produced by natural falls of water over precipices, and in the mountains (see page 278 of this Volume); but perhaps we are indebted for the first accurate theory of it to Professor Venturi.

That philosopher, in his experimental researches concerning the lateral communication of motion in fluids, proves that the water-blowing machine affords air to the furnace, by the accelerating force of gravity and the lateral communication of motion combined together. He begins with an idea, which, he candidly acknowledges, did not escape the penetration of Leonardo Da Vinci. Suppose a number of equal balls to move in contact with each other along the horizontal line AB (Plate XLVI. fig. 1.). Imagine them to pass with an uniform motion, at the rate of four balls in a second. Let us take BF, equal to 16 feet English. During each second four balls will fall from B to F, and their respective distances in falling will be nearly BC = 1, CD, = 3, DE = 5, EF = 7. We have here a very evident representation of the separation, and successive elongation, which the accelerating force of gravity produces between bodies which fall after each other.

The rain water flows out of gutters by a continued current; but during its fall it separates into portions in the vertical direction, and strikes the pavement with distinct blows. The water likewise divides, and is scattered in the horizontal direction. The stream which issues out of the gutter may be one inch in diameter, and strike the pavement over the space of one foot. The air which exists between the vertical and horizontal separations of the water which falls, is impelled and carried downwards. Other air succeeds laterally; and in this manner a current of air or wind is produced round the place struck by the water. Hence the following idea of a water-blowing machine:

Let BCDE (fig. 2.) represent a pipe, through which the water of a canal AB falls into the lower receiver MN. The sides of the tube have openings all round, through which the air freely enters to supply what the water carries down in its fall. This mixture of water

and

and air proceeds to strike a mass of stone Q; whence rebounding through the whole width of the receiver MN, the water separates from the air, and falls to the bottom at XZ, whence it is discharged into the lower channel or drain, by one or more openings TV. The air being less heavy than the water, occupies the upper part of the receiver; whence being urged through the upper pipe O, it is conveyed to the forge.

It has been supposed by some eminent chemists, that the air which passes through the pipe O is furnished by the decomposition of water. To ascertain whether this be the case or not, our author formed a water-blowing engine of a small size. The pipe BD was two inches in diameter, and four feet in height. When the water accurately filled the section BC, and all the lateral openings of the pipe BDEC were closed, the pipe O no longer offered any wind. It is therefore evident, that in the open pipes the whole of the wind comes from the atmosphere, and no portion is afforded by the decomposition of water. It remains, therefore, to determine the circumstances proper to drive into the receiver MN the greatest quantity of air, and to measure that quantity.

1. To obtain the greatest effect from the acceleration of gravity, it is necessary that the water should begin to fall at BC, (fig. 2.) with the least possible velocity; and that the height of the water FB should be no more than is necessary to fill the section BC. Our author supposes the vertical velocity of this section to be produced by an height or head equal to BC.

2. We do not yet know, by direct experiment, the distance to which the lateral communication of motion between water and air can extend itself; but we may admit with confidence, that it can take place in a section double that of the original section with which the water enters the pipe. Let us suppose the section of the pipe BDEC to be double the section of the water at BC; and, in order that the stream of fluid may extend and divide itself through the whole double section of the pipe, some bars, or a grate, are placed in BC, to distribute and scatter the water through the whole internal part of the pipe.

3. Since the air is required to move in the pipe O with a certain velocity, it must be compressed in the receiver. This compression will be proportioned to the sum of the accelerations, which shall have been destroyed in the inferior part KD of the pipe. Taking KD $= 1{,}5$ feet, we shall have a pressure sufficient to give the requisite velocity in the pipe O. The sides of the portion KD, as well as those of the receiver MN, must be exactly closed in every part.

4. The lateral openings in the remaining part of the pipe BK may be so disposed and multiplied, particularly at the upper part, that the air may have free access within the tube. We will suppose them to be such that 0,1 foot height of water might be sufficient to give the necessary velocity to the air at its introduction through the apertures.

All these conditions being attended to, and supposing the pipe BD to be cylindrical, it is required to determine the quantity of air which passes in a given time through the circular section KL. Let us take in feet $KB = 1{,}5$; $BC = BF = a$; $BD = b$. By the common theory of falling bodies, the velocity in KL will be $7{,}76\sqrt{(a+b-1{,}4)}$; the circular section KL $= 0{,}785\,a^2$. Admitting the air in KL to have acquired the same velocity as the water, the quantity of the mixture of the water and air which passes in a second through KL is $= 6{,}1\,a^2\sqrt{(a+b-1{,}4)}$. We must deduct from the quantity $(a+b-1{,}4)$ that height which answers to the velocity the water must lose by that portion of velocity which it communicates to the air laterally introduced; but this quantity is so small that it may be neglected in the calculation. The water which passes in the same time of one second thro' BC is $= 0{,}4\,a^2\sqrt{(a+0{,}1)}$. Consequently, the quantity of air which passes in one second through KL, will be $= 6{,}1\,a^2\sqrt{(a+b-1{,}4)} - 0{,}4\,a^2\sqrt{(a+0{,}1)}$, taking the air itself, even in its ordinary state of compression, under the weight of the atmosphere. It will be proper, in practical applications, to deduct one fourth from this quantity; 1. On account of the shocks which the scattered water sustains against the inferior part of the tube, which deprive it of part of its motion; and, 2. Because it must happen that the air in LK will not, in all its parts, have acquired the same velocity as the water.

If the pipe O do not discharge the whole quantity of air afforded by the fall, the water will descend at XZ; the point K will rise in the pipe, the afflux of air will diminish, and part of the wind will issue out of the lower lateral apertures of the pipe BK.

We shall not here examine the greater or less degree of perfection of the different forms of water blowing machines which are used at various iron forges; such as those of the Catalans, and elsewhere. These points may be easily determined from the principles here laid down, compared with those established in the articles *Resistance of Fluids (Encycl.)*, and Dynamics (*Supplement.*).

WEAVING (see *Encycl.*) is an operation, which, by means of a well-known instrument called the *weaving-loom*, has hitherto been performed by bodily labour. That labour is pretty severe; and Mr Robert Millar, an ingenious calico-printer in the county of Dumbarton, Scotland, wishing to lessen it, invented, some years ago, a weaving-loom, which may be wrought by water, steam, horses, or any other power. For his invention he received a patent, dated June 26th 1796; and though truth compels us to say, that we do not think it likely to emulate the spinning machine of Arkwright, it is sufficiently ingenious to deserve notice in a Work of this kind. The following is his own description of his patent weaving-loom:

Fig. 1. (Plate L.) represents a side view of the loom, AA, BB, CC, DD, being the frame. *a* is an axis (which we shall call the spindle) across the frame. On this axis is a sheeve *b*, two inches thick, having a groove round it, two inches deep, and half an inch wide. The bottom of this groove is circular, except in one part *c*, where it is filled up to the top; a lever *d* rests on the bottom of this groove, and is lifted up by it when the elevation *c* comes round to the situation represented in the figure. By this motion, the lever *d* acts on the ratchet-wheel *e* by the catch *t*, and draws it forward one tooth, each revolution of the sheeve. This ratchet wheel is in an iron frame *g g*, which also properly carries the two catches *t* and *u*, which are connected with it at *v*. The catch *u* holds the ratchet-wheel in its position, while the lever *d*, and the catch *t*, are moved by the groove *c* in the sheeve. On the arbor

 of

Weaving of the ratchet is a small pinion *h*, working in the wheel *f*; this wheel is fixed on the end of the roller *e* of fig. 3. On the side of the sheeve *b* is fixed a wiper *k*, which lifts the treadle *l*. This treadle turns on its joints in the sheeve E, which is fixed to the side of the frame A and D; it is kept pressing on the bottom of the groove in the sheeve by a spring *m*, fixed to the frame side A, and having a slender rod *n* from its extremity, joining it with the treadle at *l*. From the point of the treadle there goes a belt *o*, which passes over the pulley *p*, which is seen edgewise in this figure, and is joined to the top of the fly pin *q*, of fig. 2. At the end of the frame A is the short post F; on this rests the yarn-beam *j*, having a sheeve *r*, over which passes a cord, having a weight *s* suspended to it. The other end of this cord is fastened to the spring *v*; the weight causes the yarn-beam to stretch the web from the ratchet wheel *e*, with its catch *u*; and the spring *v* allows the rope to slide on the sheeve as the ratchet is drawn round during the working.

Fig. 2. is a front view of the loom. *a a* is the spindle which carries the sheeve *b*, and the wipers *d* and *d*, which move the treadles *w*, *w*, of fig. 1. These use the treadles of the headles, with which they are connected by cords from the shafts of the headles *s*, *s*. From the upper shaft there go two leathern belts *f*, *f*, to the roller *y*, furnished each with a buckle, for tightening them at pleasure. The two wipers *c*, *c*, on the shaft *a*, which serve for taking back the lay, have the two treadles *x*, *x*, in fig. 3. with a belt from each passing over the roller *h* 2 of fig. 1. and fixed to the sword of the lay. From the swords of the lay forward is fixed a belt to each end of the roller *i*; from this roller there goes a cord to the spring *j*, which serves for taking forward the lay which is hinged on the rocking tree *t*. The star-wheel *b* of fig. 3. and the sheeve *b* of fig. 1. are fixed to the opposite ends of the spindle *a* without the frame; and both the wheel and sheeve have a wiper *k* fixed to them for moving the treadles. In order to drive the shuttle, the belts *o*, *o*, go from the points of the treadles, over the pulleys *p*, *p*, to the top of the fly-pin *q*: This turns on a pin joint in a rail *r*, which goes across the loom. From its lower end there go two small cords to the shuttle drivers *g*, *g*, which slide on the iron rods *n*, *n*. A long iron rod *v* goes across the lay, and is hung on two centres at the ends. In this rod *v* are fixed two small crooked wires *w*, *w*, which are more distinctly marked in the little figure *w* above, which represents a section of the lay. The dot at the lower end of the wire *w*, in this figure, is the section of the rod *v*. The shuttle passes between these wires and the lay every shot, and lifts them up, causing the rod *v* to turn round a little. But if the shuttle should not pass these wires, nor lift them, it would be drawn home by the lay, and destroy the web. To prevent this, there is fixed on one end of the rod *v* a stout crooked wire *z*, having a broad or flat head, which naturally rests on a plate of iron, marked and fixed to the back of the lay. This plate has a slit in its middle about an inch deep. In this slit rests the rod *a* 2 of fig. 3. on which is a short stud which is caught by the wire *z* when the wire *w* is not lifted back by the passing shuttle. This will stop the lay from coming home, and will set off the loom.

Fig. 3. is another side-view of the loom opposite to fig. 1. On the spindle *a* is the star wheel *b*, on the outside of the loom-frame, on the arms of which wheel is fixed the wiper *k*, as the similar wiper is fixed to the sheeves on the other end of the spindle. The wipers which drive the shuttles are fixed on opposite squares of the spindle, and work alternately. Below the star-wheel is a pinion *c*, which is on a round spindle, turned by the water-wheel, by means of a wheel on this spindle. In a wheel on this spindle are two studs, on which the pinion *c* slides off and on as the loom is set off and on by the lever *d*. At the farther end of this lever is the weight *s*, hanging by a cord which passes over a pulley *t*, fixed at the outer end of the spring-catch on which the lever *d* rests; and thus the loom is drawn in at the upper end of the lever *d*. But when the shuttle does not lift the wire *z*, it catches on the stud on the rod *a* 2, which is connected with the spring-catch, and the lever *d* flies off with the weight *s*, and the loom stops working. On the head of the post F is the yarn-beam. The rollers *e* and *f* are cylinders, pressed together by a screw-lever, and take away the cloth between them at a proper rate. In the roller *f* is a groove for a band for driving the roller *g*, on which the cloth winds itself as it is wrought. Wherever springs are mentioned to be used in the above description, weights may be used in their stead, and to the same effect, and more especially upon the treadle of fig. 1. for driving the shuttle.

WEIGHTS AND MEASURES, in commerce, are so various, not only in different countries, but even in different provinces of the same country, and this variation is the source of so much inconveniency in trade, that writers on political and commercial economy have proposed various methods for fixing an universal and immoveable standard of weights and measures for all ages and nations. Sir James Stewart Denham's speculations on this subject have been noticed in his life published in this *Supplement*; Mr Whitehurst's ingenious contrivance for establishing a standard of weights and measures has been mentioned under the title MEASURE (*Encycl.*); and the new table of weights and measures, which the French republicans wish to impose upon all Europe, is given (*Encycl.*) under the title REVOLUTION, n° 183.

As these measures occur frequently, even in English translations of French books of value, we shall here give such an account of them as may enable the reader to reduce them with ease to the English standards. They are of five kinds; *measures of length*, *of capacity*, *of weight*, *of superficies for land*, *and of wood for fuel*. For every kind, there are many measures of different sizes, one of which has been taken as the basis of all the rest, and its name assumed as the root of their names. Thus METRE is called the principal measure of length; LITRE, of capacity; GRAMME, of weight; ARE, of superficies of land; and STERE, of wood for fuel. These words being the radical terms of the names of other measures of length, capacity, &c. a relation is hereby preserved between the names.

The measures of length above the *metre*, are ten times, a hundred times, a thousand times, ten thousand times, greater than the metre. The measures of length below the metre, are ten times, a hundred times, a thousand times, less. To form the names of these measures, other words which indicate the relations of *ten times*, *a hundred*

Weights. *hundred times*, greater; and of *ten times*, a *hundred times*, less. &c. are placed before the word *metre*. The same annexes have been used to form the names of measures, greater or less, than the *litre*, the *gramme*, &c. It is necessary, therefore, to state in this place the English equivalents of only the *metre*, the *litre*, the *gramme*, the *are*, and the *stere*.

The METRE = 3.28084 feet English.

The LITRE = 61.0243 cubic inches, or $1\frac{101}{131}$ pint ale measure.

The GRAMME, or cubic *centi-metre* of water, at the freezing point, = $\frac{1}{454}$ lb. averd. or $\frac{1}{28}$ of an ounce, or $\frac{9}{16}$ of a dram nearly.

The ARE = $1076\frac{1}{7}$ square feet, or $119\frac{1}{2}$ square yards, or $\frac{1}{40}$ of an acre nearly.

The STERE, or cubic metre = 35.31467 cubic feet.

The better part of our countrymen, not choosing to adopt the weights and measures prescribed to them by the French Convention and the National Institute, Sir George Shuckburgh Evelyn, Bart. turned his attention to this subject, and published, in the Philosophical Transactions for 1798, an account of some endeavours to ascertain a standard of weights and measures. The principles upon which he proceeded are the same with Mr Whitehurst's; but he has carried his experiments much further than his predecessor, and seems to have conducted them with greater accuracy. His memoir is hardly susceptible of abridgment; and our limits do not permit us to insert it entire. This is indeed unnecessary, if it be true, as another ingenious gentleman alleges *, that we are in the actual possession, and the constant use, of a standard both for weight and measure, as invariable as that now used in France. This standard he finds in the foot measure, and in the avoirdupoise, or, as he thinks it ought to be called, the *decade* ounce weight.

* H. Goodwin, Esq; in *Nicholson's Journal*, vol iv. p. 163, &c.

The decade ounce weight of pure rain, or distilled water, at 60° of heat, is generally allowed to be equal in bulk to the one-thousandth part of the cubic foot. Were 44.3511 parts out of 10000, or about $\frac{1}{225}$th part added to the present Winchester bushel, that bushel would then contain exactly 10 cubic feet or 10000 oz. of distilled water, at 60° of heat.

Our author then gives comparative tables between this system and that which is now established in France. Taking the metre at 3 French feet, and 11.296 lines †, and the French foot to be to the English as 1 : 1.065752004 ‡, one French foot will be equal to 10.65752004 English decades, or tenths of an English foot: hence he calculates the following

† *Journal de Phys.* vol v. p. 460.

‡ *Phil. Trans.* 1768, p. 326. and *Connoissance des Temps*, 1795.

COMPARATIVE TABLES, English with French.

LONG MEASURE.

Long decade.	Metre.		Metre.	Long decades.
1	= 0.03047983	fere	1 =	32.808583358, &c. or inches 39.3703.

SQUARE MEASURE.

Square decades.	Ares.		Ares.	Square decades.
1	= 0.0000092902	fere	1 =	107640.3142, or sqr. inch. 155002.052448

CUBE MEASURE.

Cube decades.	Litres.		Litre.	Cube decades.
1	= 0.02831637	fere	1 =	35.3152622, &c. or cub. inch. 61.0247727

WEIGHTS.

Avoird or decade oz.	Grammes.		Gramme.	Decade oz.
1	= 28.31637	fere	1 =	0.03531526, &c. or grains, 15.45042625

Long, Square, or Cube, decades are reduced to Long, Square, or Cube, English inches by multiplying by 1.2, 1.44, 1.728; and decade ounces are reduced to grains, containing 7000, or 5760, to the lb. Avoird. or Troy, by multiplying the ounce by 437.5 = the number of grains in an avoirdupoise ounce.

Our author, who seems to have paid much attention to weights and measures, observes, that a standard measure for the purposes of trade, in particular, as well as for others, that would uniformly give an accurate result, and could be easily made, examined, and ascertained, by common mechanics, which neither our present liquid nor dry measures evidently can, would surely be an acquisition of great value. Such an one, he presumes, would be the following: A square pyramid, whose perpendicular height is exactly thrice the length of the side of the base: for such an one, and every section of it, made by a plane parallel to its base, would, in the first instance, possess, and, in every subdivision, retain these remarkable properties.

1st, Similar comparative dimensions to those above given, for the original pyramid, *i. e.* every smaller pyramid, formed by the above mentioned parallel section, would have its perpendicular height thrice the length of the side of its base; and,

2dly, The length of the side of each base will always indicate, or equal the cube root of the solid content of the pyramid; *e. g.* If the length of the side of the base be 3, the solid content will be the cube of 3, *viz.* $3 \times 3 \times 3 = 27$.

We do not perceive very clearly the great value of this standard; but Mr Goodwyn says, that he has been many years in the habit of using a pyramid measure to examine corn; and is perfectly convinced that such a one will indicate a far more accurate result than can arise from the manner in which corn is measured by the bushel. This we are bound to believe; for it is absurd to oppose theories to a fact ascertained by experience.

Westringia. WESTRINGIA, a new genus of plants described by J. E. Smith, M. D. president of the Linnæan Society of London. It was first discovered in New Holland by Dr Solander, who called it *Cunila Fruticosa*, though it is totally different from the CUNILA (see that article, *Encycl.*), and more resembles rosemary, from which, however, it is likewise different. Its peculiar character is: *Calyx semiquinquefidus, pentagonus; corolla resupinata, limbo quadrifido, lobo longiore erecto, bipartito: Stamina distantia, duo breviora (inferiora) abortiva.* Dr Smith assigns it rather to the *didynamia angiospermia*, placing it immediately after the *Teucrium*, than to the *diandria* class of plants.

Wheat. WHEAT (see TRITICUM, *Encycl.*) has for some years past been at so very high a price, that every hint for increasing its quantity or improving its quality is intitled to notice. In the Leicester Journal for the 6th of December 1799, there is an ingenious paper on the subject of transplanting wheat, as a means of providing against

against the expected scarcity of that necessary of life. It is recommended "to sow, in dry land, at the usual season, as much corn as may be deemed necessary to plant in the spring any number of acres which may be occupied with that article in the following year. When the soil is prepared, a furrow is to be made with a very small plough and one horse, in the centre of the ridge or land, returning back in the same track (this time only of every ridge); then turn towards the left hand, and plough another furrow, about eight or nine inches from the first furrow, turning always to the left hand, till the whole ridge is finished; it will then be formed into trenches, in parallel lines of about eight or nine inches asunder, and imitate what gardeners term drawing of drills. In these furrows the plants are to be laid." Mr John Ainsworth of Clen the experienced author of this communication, says he has practised this method with the most complete success.

It has been likewise practised, on a small scale, with equal success, but we know not in what county. About the end of August 1783, that gentleman threw a small quantity of wheat, which near two years before had been steeped and limed (see WHEAT, *Encycl.*) into an unmanured corner of his garden. In the beginning of February following he had a piece of ground (also unmanured) dug in an open part of his orchard, and he transplanted it on beds of six rows wide, at nine inches asunder every way. It tillered, and spread over the ground so completely, as to prevent even a weed growing among it. It produced admirable corn, and at the rate of near four quarters per acre.

From accurate calculations which he then made, he found that an acre, supposing the seed to be very good, and the plants set at the distance above mentioned, would require only *half a peck* of seed.

Besides the saving of the seed, there are two other material advantages which attend such a method; one is, that some suitable crop may be on the ground all the winter for use; and the other is, that ploughing the ground so late as February, will effectually bury and destroy those weeds which were beginning to vegetate; and before others can spring up, the corn plants have taken to the ground, and so spread over it that the weeds cannot rise, by which means there is a very clean crop, and all the customary expence for weeding is saved.

This author seems to think that wheat will thrive as well, and produce as full a crop, when sown in the spring, as if it had been committed to the ground in the preceding autumn. In the southern counties of England we doubt not but it may; but the case is otherwise in Scotland, where the spring is not so early, and where, from the narrowness of the island, the frost is seldom so severe. We agree, however, with Dr Pike, in thinking it a pity that the way of setting wheat (as done in Norfolk and Suffolk) is not every where more general. The process is indeed tedious and troublesome; and we have often wondered that, among the numberless machines lately contrived to lessen manual labour, none has been invented for dibbling wheat expeditiously and accurately. We are therefore pleased to learn, that Dr Pike himself has turned his attention to the subject, and hopes in the course of this year (1800) to present the public with a *method of setting wheat at* PERFECTLY EXACT *distances through a whole field, and as* EXPEDITIOUSLY *as the common broadcast sowing, which can therefore be applied to farms of any magnitude;* and when a peck of seed is found to be sufficient for an acre (and in some land much less), the saving on a large farm must be immense. We trust to the liberality of his profession, that he will not take out a patent for his invention.

Though we have elsewhere given the usual recipes for preventing smut in wheat, it would be improper to conclude this article without mentioning the very simple one which Mr Wagstaffe of Norwich has uniformly found attended with complete success. This consists in nothing more than immersing the seed in pure water, and repeatedly scouring it therein, just before it is sown or dibbled in the soil. Whether well, spring, or river water be used, is indifferent; but repeated stirring and change of water is essential to remove the particles of infection that may have imperceptibly adhered to the seeds thus purified. The subsequent crop will be perfect in itself, and its seeds, he says, successively so likewise, if there are no adjacent fields from whence this contamination may be wafted. He recommends the same washing, and for the same reason, of barley and oats before they be sown.

WILKIE (William, D. D.), the author of an heroic poem, intitled the *Epigoniad*, was born in the parish of Dalmeny, in the county of West-Lothian, on the 5th of October 1721. He was descended of an ancient family in that county, though his father rented only a small farm, and was poor and unfortunate through life. He was able, however, to give his son a liberal education; and that son, it is said, discovered so early a propensity to the study of poetry, that he began to write verses in his tenth year.

As this wonderful prematurity of genius was never heard of during Wilkie's life, it will probably be considered as a story fabricated to raise the Scottish poet to the same eminence with Pope, whose versification he is allowed to have imitated with success. We have no doubt but that Wilkie wrote in early life the description of a storm, which is published in the 9th volume of the Statistical Account of Scotland; but that he wrote it in his tenth year is not proved, and is highly improbable. The poem displays a notion—a confused notion indeed—of the laws of electricity, which a boy in his tenth year, and at a period when electricity was little understood, could not have acquired.

Having learned the rudiments of the Latin tongue at the parish-school of Dalmeny, young Wilkie was, at the age of thirteen, sent to the university of Edinburgh, where he was soon distinguished by his originality of thought, and by his rapid progress in erudition and science. Among his fellow-students he was most closely associated with Dr Robertson the historian, Mr John Home the poet, Dr M'Ghie (A), who afterwards obtained

(A) According to Sir John Hawkins, this man bore arms on the side of government at the battle of Falkirk 1745. After which, taking a degree in physic, he went to London in hopes of employment through the interest

Wilkie.

tained the friendship of Johnson, and became a member of the Ivy lane Club; and a Mr Cleghorn, who promised be an ornament to the university, in which he was afterwards a professor, but died before he had time to realize the fond hopes of his friends. During the course of his education, Wilkie became acquainted with the celebrated David Hume and Dr Ferguson, and at a later period with Dr Adam Smith, the far-famed author of "The Wealth of Nations." Of all those men he regarded Dr Ferguson with the greatest affection, and Dr Smith with the greatest admiration. This last writer he considered as equal to Robertson and Hume in erudition, and vastly their superior in originality and invention; and this opinion he cherished to the day of his death.

Before he had completed his education, his father died, leaving him no other inheritance than the stock and unexpired lease of his farm, and the care of his three sisters. Wilkie, therefore, turned much of his attention to agriculture, in which he became eminent, not merely as a theorist, but as a practical farmer. He had too much science to be the slave of ancient prejudice, and too much judgment to be hurried into hazardous experiments by the charms of untried speculation. One of his sisters being married to a skilful, though unlettered farmer, he availed himself of his brother's experience; and upon the facts and maxims derived from him built a system of practical farming, which fully answered his own expectation, and obtained the applause of all his neighbours.

He still prosecuted his studies in the university, and without ceasing to be a farmer became a preacher in the church of Scotland. For some years this made no alteration in the mode of his living. He preached occasionally for the ministers in his neighbourhood; cultivated his farm; read the classics; and, enamoured of the simple sublimity of Homer, projected an epic poem on the Homeric model. The subject of his intended poem he drew from the fourth book of the *Iliad*, where Sthenelus gives Agamemnon a short account of the sacking of Thebes; and as that city was taken by the sons of those who had fallen before it, Wilkie gave to his poem the quaint title of *Epigoniad*, from the Greek word ἐπίγονοι, which signifies *descendants*. It is not our business to write a criticism upon this poem. The subject was ill-chosen; for the learned reader has enough of the heroic ages in the immortal poems of Homer and Virgil, and in those ages the unlearned reader can feel no interest. The Epigoniad, therefore, though composed in smooth and elegant verse, with due attention to ancient manners, and constructed on the most regular plan, has fallen into neglect, from which no critic or biographer will ever rescue it.

In the year 1753, Mr. Wilkie was ordained minister of Ratho, in consequence of a presentation from the Earl of Lauderdale, who knew his worth and admired his genius. Without neglecting his favourite amusements of husbandry, or the study of the belles lettres, he discharged with fidelity the duties of a Christian pastor, was famed for his original and impressive mode of preaching, and soon came to be loved as well as esteemed by his rural flock.

In the year 1757 the Epigoniad was published, the result of fourteen years study and application, which might surely have been more usefully employed on some other work; and in 1759 a second edition was called for, to which he added *A Dream in the manner of Spenser*. He was, the same year, chosen professor of natural philosophy in the university of St Andrew's; an office for which it is difficult to conceive how he could have been fitted by the study of epic poetry, and close attention to the cultivation of his farm. He was, however, a man of a vigorous mind, and we never heard that he disgraced his electors.

When he removed to St Andrew's, his whole fortune exceeded not L. 200 Sterling; a proof that his Epigoniad had not enriched him. With this sum he purchased a few acres of land in the neighbourhood of the city, carried his two unmarried sisters with him, and continued to live in the university exactly as he had lived at Ratho. In his professorial career there was nothing remarkable. He patronised genius, especially poetical genius, in the young men who attended his lectures, and by them was, of course, loved and esteemed: (See FERGUSSON in this *Suppl.*). In the year 1768 he published a volume of fables of no great value, previous to which the university conferred upon him the degree of D. D.; and he died, after a lingering illness, on the 10th of October 1772.

The manners of Dr Wilkie were singular, and in some respects disgusting. He has been severely blamed for his penuriousness, but, in our opinion, unjustly. His father had left him in debt, with nothing but the profits which he might make of a small farm to discharge that debt, and to support himself and three sisters. In him, therefore, rigid economy was, for many years, a virtue; and he knows little of human nature, who can blame a man for not breaking habits which it had been the duty, as well as the business, of a great part of his life to form. Amidst his most rigid and offensive economy, he was liberal in his donations to the poor.

He had been seized, while minister of Ratho, with an unformed ague, of which he never got entirely rid. For this complaint he thought an extraordinary perspiration necessary, and generally slept, in winter, under twenty-four blankets. He had an utter aversion from clean linen, and has been known to bargain, when he staid a night from home, not only for the proper quantity of blankets to his bed, but also for sheets, which had been used by some other person, and rendered sufficiently dirty to please his feeling. It will easily be conceived that such a man was, to the last degree, slovenly in his dress.

Suspicions have been thrown out by his latest, and we believe his only, biographer, that Dr Wilkie's belief of the Christian religion was neither orthodox nor steady. Not having had the pleasure of his acquaintance, we cannot positively say that these suspicions are groundless; but the writer of this article has conversed much about the author of the Epigoniad with a clergy-

rest of his countrymen, and perhaps in return for his loyalty. He was a learned, ingenious, and modest man; but so little successful in his profession, that he died of a broken heart, and was buried by a contribution of his friends.

man who knew him well, and who would have been glad to accuse him of infidelity, if he could have preferred such an accusation with truth. He was a very absent man, apt to forget what he was about even when discharging the most solemn parts of his clerical duty, and used to say of himself that he never could conduct a sacrament. From this absence of mind, and those confessions of it, may have arisen the suspicion that he was not a firm believer; but no such suspicion was ever thrown out to this writer by the clergyman already referred to.

He had one very extraordinary defect in a poet: He could not read aloud the smoothest verses, so as to preserve either the measure or the sense of them. Of this Dr Anderson has produced very complete proof in his life of Wilkie, prefixed to his poetical works in the Edinburgh edition of the British Poets. With all his defects, however, and all his foibles, he was unquestionably a genius, and, we are inclined to believe, a good man.

WINES (see that article, *Encycl.* and *Vegetable Substances, Suppl.*) are so often adulterated with minerals prejudicial to the health, that various methods have been devised for detecting the adulteration. The property which liver of sulphur (alkaline sulphures) and hepatic air (sulphurated hydrogen) possess of precipitating lead in a black form, has been long ago made public; and this property has been employed to determine the quality of wines by means of the *liquor probatorius Wirtembergensis*, or Wirtemberg proving liquor. But in trying wines supposed to have been adulterated, this proof does more hurt than service, because it precipitates iron of the same colour as the pernicious lead. Many wine-merchants, therefore, of the greatest respectability, rendered by these means suspected, have been ruined.

The following is recommended by M. Hanhemann as a better test of sound wines than the proving liquor of Wirtemberg. Mix equal parts of oyster shells and crude sulphur in a fine powder, and put the mixture into a crucible. Heat it in a wind furnace, and increase the fire suddenly, so as to bring the crucible to a white heat, for the space of 15 minutes. Pulverise the mass when it is cool, and preserve it in a bottle closely stopped.

To prepare the liquor, put 120 grains of this powder, and 120 grains of cream of tartar (acidulous tartarite of potash), into a strong bottle; fill the bottle with common water, which boil for an hour, and then let it cool; close the bottle immediately, and shake it for some time: after it has remained at rest to settle, decant the pure liquor, and pour it into small phials capable of holding about an ounce each, first putting into each of them 20 drops of muriatic acid. They must be stopped very closely with a piece of wax, in which there is a small mixture of turpentine.

One part of this liquor, mixed with three parts of suspected wine, will discover, by a very sensible black precipitate, the least traces of lead, copper, &c. but will produce no effect upon iron, if it contains any of that metal. When the precipitate has fallen down, it may still be discovered whether the wine contains iron, by saturating the decanted liquor with a little salt of tartar (tartareous acidulum of potash), by which the liquor will immediately become black. Pure wines remain clear and bright after this liquor has been added to them.

WOOD-CUTS are engravings on wood, commonly on box, which, in many cases, are used with advantage instead of copper-plates. The art of cutting or engraving on wood is undoubtedly of high antiquity; for Chinese printing is a specimen of it. (See CHINA, n° 127 *Encycl.*) Even in Europe, if credit be due to Papillon, this art was practised at a period considerably remote; for he mentions eight engravings on wood, entitled, "A representation of the warlike actions of the great and magnanimous Macedonian king, the bold and valiant Alexander; dedicated, presented, and humbly offered, to the most holy father, Pope Honorius IV. by us Alexander Alberic Cunio Chevalier, and Isabella Cunio, &c." This anecdote, if true, carries the art of cutting in wood back to 1284 or 1285; for Honorius occupied the papal throne only during these two years. Even this is not the remotest period to which some have carried the art in Europe; for the use of seals or signets being of very high antiquity, they imagine that the invention of wood-cuts must be coeval with them. The supposition is certainly plausible, but it is not supported by proof. The earliest impression of a wooden-cut, of which we have any certain account, is that of St Christopher carrying an infant Jesus through the sea, in which a hermit is seen holding up a lantern to shew him the way; and a peasant, with a sack on his back, climbing a hill, is exhibited in the back ground. The date of this impression is 1423.

In the year 1430 was printed at Haarlem, "The history of St John the evangelist and his revelation, represented in 48 figures in wood, by Lowrent Janson Coster;" and, in 1448, Jorg Schappf of Augsburg cut in wood the history of the Apocalypse, and what was called *The poor man's bible*. (See ENGRAVING, *Encycl.* page 668.)

A folio chronicle, published 1493 by Schedal, was adorned with a vast number of wood-cuts by William Plydenwurff and Michael Wolgemut, whose engravings were greatly superior to any thing of the kind which had appeared before them. Wolgemut was the preceptor of Albert Durer, whose admirable performances in this department of art are justly held in the highest esteem even at the present day.

About this period it became the practice of almost all the German engravers on copper to engrave likewise on wood; and many of their wood cuts surpass in beauty the impressions of their copper-plates. Such are the wood-cuts of Albert Aldtorfer, Hisbel Pen, Virgil Soles, Lucas van Cranach, and Lucas van Lyden, the friend and imitator of Albert Durer, with several others.

It appears that the Germans carried this art to a great degree of perfection. Hans or John Holbien, who flourished in 1500, engraved the *Dance of Death*, in a series of wooden-cuts, which, for the freedom and delicacy of execution, has hardly been equalled, and never surpassed.

Italy, France, and Holland, have produced many capital artists of this kind. Joan. Tornæsium printed a bible at Lyden, in 1554 (a copy of which we have seen), with wooden-cuts of excellent workmanship. Christopher Jegher of Antwerp, from his eminence in the art, was employed by Rubens to work under his inspection,

Wood-cuts. inspection, and he executed several pieces which are held in much estimation; the character of these is boldness and spirit.

The next attempt at improvement in this art was by Hugo da Carpi, to whom is attributed the invention of the *chiaro scuro*. Carpi was an Italian, and of the 16th century; but the Germans claim the invention also, and produce in evidence several engravings by Mair, a disciple of Martin Schoen, of date 1499. His mode of performing this was very simple. He first engraved the subject upon copper, and finished it as much as the artists of his time usually did. He then prepared a block of wood, upon which he cut out the extreme lights, and then impressed it upon the print; by which means a faint tint was added to all the rest of the piece, excepting only in those parts where the lights were meant to predominate, which appear on the specimens extant to be whitened with white paint. The drawings for this species of engraving were made on tinted paper with a pen, and the lights were drawn upon the paper with white paint.

There is, however, a material difference between the *chiaro scuros* of the old German masters and those of the Italians. Mair and Cranach engraved the outlines and deep shadows upon copper. The impression taken in this state was tinted over by means of a single block of wood, with those parts hollowed out which were designed to be left white upon the print. On the contrary, the mode of engraving by Hugo da Carpi was, to cut the outline on one block of wood, the dark shadows upon a second, and the light shadows, or half tint, upon a third. The first being impressed upon the paper, the outlines only appeared: this block being taken away, the second was put in its place, and being also impressed on the paper, the dark shadows were added to the outlines; and the third block being put in the same place upon the removal of the second, and also impressed upon the paper, made the dim tints, when the print was compleated. In some instances, the number of blocks were increased, but the operation was still the same, the print receiving an impression from every block.

In 1698, John Baptist Michel Papillon practised engraving on wood with much success, particularly in ornamental foliage and flowers, shells, &c. In the opinion, however, of some of the most eminent artists, his performances are stiff and cramped. From that period the art of engraving on wood gradually degenerated, and may be said to have been wholly lost, when it was lately re-invented by Mr Bewick of Newcastle.

This eminent artist was apprentice to Mr Bielby, an engraver on metal of the very lowest order, who was seldom employed in any thing more difficult than the cutting of the face of a clock. Application having been made to this man for a wood-cut or two of the most trifling description, the job was given to Thomas Bewick; by whom it was executed in such a manner, that Mr Bielby, who was accustomed to employ his apprentices in such work, advised him to prosecute engraving in that line. The advice was followed; and young Bewick inventing tools, even making them with his own hands, and sawing the wood on which he was to work into the requisite thickness, proceeded to improve upon his own discoveries, without assistance or instruction of any kind. When his apprenticeship expired, he went to London, where the obscure wood-engravers of the time wished to avail themselves of his abilities, while they were determined to give him no insight into their art. He remained some years in London; and during that time, if we mistake not, received from the *Society for the Encouragement of Arts, &c.* a premium of considerable value for the best engraving in wood. Returning to Newcastle, he entered into copartnership with his old master; and established his reputation as an artist by the publication of his admirable History of Quadrupeds. This was followed by his History of Birds, of which only one volume has yet (1800) appeared.

John Bewick, brother to Thomas, learned the art of him, and practised it for several years in London with great applause. His abilities, however, though respectable, were not, by the best judges, deemed so brilliant as his brother's; and owing to bad health, and the nature of his connection with the booksellers and others, he seems not to have advanced the art beyond the stage at which he received it. He died, three or four years ago, at Newcastle.

Mr Nesbit, who executed the admirable Hudibras published by Vernor and Hood (A), and Mr Anderson, whose beautiful cuts adorn the poem entitled *Grove Hill*, were the next, and hitherto have been the last of Thomas Bewick's pupils, who have appeared before the public as artists. By these gentlemen we are authorized to say, that the method practised by the ancient engravers on wood, whose works are still admired, must have been different from that of Bewick and his pupils. What that method was seems to be altogether unknown. Papillon, who writes the best history extant of the art, guesses indeed in what manner the old engravers proceeded so as to give to their works the spirit and freedom for which they are famed; but that his guesses are erroneous seems evident from the stiffness of his own works. The principal characteristic in the mechanical department of the productions of the ancient masters is the crossing of the black lines, which Papillon has attempted with the greatest awkwardness, though it seems to have been accomplished by them with so much ease, that they introduced it at random, even where it could add nothing to the beauty of the piece. In Bewick's method of working, this cross hatching is so difficult and unnatural, that it may be considered as impracticable (B).

The engravers of Bewick's school work on the end of the wood which is cut across the trunk of the tree, in

(A) The designs were by Thornton; and the cuts from them have been compared to Holbein's far-famed Dance of Death.

(B) Mr Nesbit has indeed introduced something of it into two or three of his pieces, merely to shew that he *could* do it; but so great was the labour, and so little the advantage of this improvement, if such it can be called, that probably it will not be attempted again.

Wood-cuts. is pieces of the proper thicknefs. As wood-cuts are generally employed in the printer's prefs amidft a form of types, this thicknefs muft be regulated by the height of the types with which they are to be ufed. The tools employed are nearly the fame with thofe ufed in copperplate engraving, being only a little more deep, or lozenge, as engravers call it. They muft have points of various degrees of finenefs for the different purpofes to which they are applied, fome of them being fo much rounded off at the bottom as to approach to the nature of a goodge, whilft others are in fact little chiffels of various fizes. Thefe chiffels and goodges, to which every artift gives the fhape which he deems moft convenient, are held in the hand in a manner fomewhat different from the tool of the engraver on copper, it being neceffary to have the power of lifting the chips upwards with eafe. To attempt a defcription of this in writing would be in vain; but it is eafily acquired, we are told, by practice.

The pupils of the fchool of Bewick confider it as quite improper to fpeak of his invention as a revival of the ancient art. Some old prints, it is true, have the appearance of being executed in the fame way with his; but others have certainly been done by a method very different. It is therefore not fair to appreciate the prefent art by what has been done, but by what may be done; and that remains yet to be fhewn. The art is in its infancy; and thofe who are difpofed to compare it with the art of engraving on copper, ought to look back to the period when copperplate engraving was of as recent invention as Bewick's method of engraving on wood. Marc Antonio, who engraved under the direction of the great painter Raphael, thought it no mean proof of his proficiency in his art, that he was able to imitate on copper plates the wood-cuts of Albert Durer; and Papillon is highly indignant that there fhould have been perfons fo very blind as to miftake the copies for the originals. If copper has its advantages over wood in point of delicacy and minutenefs, wood has, in its turn, advantages not inferior in regard to ftrength and richnefs. Thofe prints which were executed under the aufpices of Titian and Rubens, will always remain a monument of the fpirit and vigour natural to wood engraving; and if there be not found in them all the attention to *chiaro fcuro*, which the prefent age demands, it muft not be attributed either to defect in the art, or to want of abilities in the artifts, but to the tafte of the times when *chiaro fcuro* was little underftood. It remains for fome enterprifing artift to fhew that the vigour of the ancient art may be attained by the prefent one, and at the fame time to add to that vigour thofe gradations of fhade which are fo much admired in good copperplates. As there feems to be a more perfect, or at leaft a more pleafant black produced by wood than by copperplate printing, and certainly a more perfect white (c), who will fay that any intermediate fhade whatever may not be produced by wood-cuts? To attempt this on a fmall fcale would indeed be vain, becaufe the flighteft variation, produced by a little more or lefs ink, or a harder preffure in printing, bears fuch a proportion to a very fhort line, as muft neceffarily render the attempt abortive.

Wood-engraving, therefore, muft always appear to disadvantage while it is confined to fmall fubjects, and will never reach its ftation *as a fine art*, till thofe who are engaged in its cultivation improve upon the difcoveries of one another, and apply to fubjects to which it is properly adapted. As an *economical art* for illuftrating mechanics and other fubjects of fcience, it is too little employed even in its prefent ftate. Wood-cuts, Wool-combing.

The works of Bewick and his pupils, which have hitherto been publifhed, are not numerous. Befides his quadrupeds and birds, the Hudibras by Nefbit, and the Grove Hill by Anderfon, which have been already noticed, we are acquainted with none but the following:—Goldfmith's *Traveller* and *Deferted Village* with elegant plates, all by Thomas Bewick, except one or two which were executed by John; Somerville's *Chace* by the fame artifts, executed in a ftyle of elegance which perhaps has never been furpaffed; a View of St Nicholas's Church, Newcaftle, 15 inches long, by Mr Nefbit, who received for it a filver medal from the Society for the Encouragement of Arts, and an honorary letter from the Society of Antiquaries.

WOOL-COMBING, a well known operation, which, when performed by the hand, is laborious, tedious, and expenfive. The expence of it through all England has been calculated at no lefs a fum than L. 800,000; and to leffen this expence, the Rev. Edmund Cartwright of Doncafter in Yorkfhire bethought himfelf, fome years ago, of carding wool by machinery. After repeated attempts and improvements, for which he took out three patents, he found that wool can be combed in perfection by machinery, of which he gives the following defcription:

Fig. 1. Is the crank lafher. A is a tube through which the material, being formed into a fliver, and flightly twifted, is drawn forward by the delivering rollers. B, a wheel faft upon the crofs-bar of the crank C, a wheel, on the oppofite end of whofe axis is a pinion working in a wheel upon the axis of one of the delivering rollers. Plate L.

Note, When two or more flivers are required, the cans or bafkets, in which they are contained, are placed upon a table under the lafher (as reprefented at D), which, by having a flow motion, twifts them together as they go up.

Fig. 2. Is the circular clearing comb, for giving work in the head, carried in a frame by two cranks. Fig. 3. The comb-table, having the teeth pointing towards the centre, moved by cogs upon the rim, and carried round upon trucks, like the head of a windmill. *a*, *b*, the drawing rollers. *c*, *d*, callender, or conducting rollers.

Note, Underneath the table is another pair of rollers, for drawing out the backings.

In the above fpecification, we have omitted the frame in which the machine ftands, the wheels, fhafts, &c. Had thefe been introduced, the drawing would have been crowded and confufed; befides, as matters of information, they would have been unneceffary, every mechanic, when he knows the principles of a machine, being competent to apply the movements to it.

The wool, if for particular nice work, goes through three operations, otherwife two are fufficient: the firft operation

(c) The parts of the print intended to be white are not even touched by the wood-block.

Wool-combing. operation opens the wool, and makes it connect together into a rough fliver, but does not clear it. The clearing is performed by the second, and, if neceffary, a third operation. A fet of machinery, confifting of three machines, will require the attendance of an overlooker and ten children, and will comb a pack, or 240lb. in twelve hours. As neither fire nor oil is neceffary for machine-combing, the faving of thofe articles, even the fire alone, will, in general, pay the wages of the overlooker and children; fo that the actual faving to the manufacturer is the *whole* of what the combing cofts, by the old imperfect mode of hand-combing. Machine-combed wool is better, efpecially for machine-fpinning, by at leaft 12 *per cent.* being all equally mixed, and the flivers uniform, and of any required length.

Z.

Zaminy, Zemindars. ZAMINY, in the language of Bengal, fecurity.

ZEMINDARS, the great landholders of Bengal. This is the original fenfe of the word; but it is now more ftrictly applicable to thofe who have their title conftituted or confirmed by a patent or charter from government, by which they hold their lands or Zemindaries upon certain conditions. As far as can be afcertained from the narrations of hiftory, it appears that, in times prior to the irruptions of the Mahomedans, the rajahs who held their refidence at Delhy, and poffeffed the fovereignty of Hindoftan, deputed officers to collect their revenues (Kherâje), who were called in the Indian language *Choudheries*. The word *Zemindar* is Perfian, and that language can have had no currency in the countries of India, until it was introduced by the people of Perfia. When the Emperor Shehâb ul-Dien Ghory conquered the empire of Hindoftan (A), he left Sultan Cutub ul Dien to be his viceroy at Delhy, and adminifter the government of Hindoftan. From that time the cuftoms and practices of the Mahomedans began gradually to be eftablifhed in India; their armies were fent into the countries of the reduced Rajahs, under the command of Omrahs, in order to preferve the conqueft; and lands were allotted to them to defray the expence. From hence arofe the fyftem of Jaghiredarry in Hindoftan. But when thefe Omrah Jaghiredars had eftablifhed their own ftrength, feveral of them rebelled againft the imperial authority, and afpired at the crown. Thus circumftanced, the emperors, in order to obviate thefe mifchiefs, thought it would be more politic to commit the management of the country to the native Hindoos, who had moft diftinguifhed themfelves by the readinefs and conftancy of their obedience to the fovereign power.

In purfuance of this plan, diftricts were allotted to numbers of them under a reafonable revenue (Jummah Monâfib), which they were required to pay in money to the governors of the provinces, deputed from the Emperor. And in cafe any one of the Omrahs or provincial governors fhould fwerve from his allegiance, the Zemindars of that country were to exert themfelves in fuch a manner as fhould check rebellion, and reftore good government. For this purpofe, grants of Zemindary were feverally conferred upon fuch of the Hindoos as were obedient; defcribing their apportionment of the country; and every perfon who had received a grant under the authority of the crown was thereby fully invefted with the functions of Zemindar.

Zemindars. The functions of a Zemindar are, 1ft, The prefervation and defence of their refpective boundaries from traitors and infurgents; 2dly, The tranquillity of the fubjects, the abundance of cultivators, and increafe of his revenue. 3dly, The punifhment of thieves and robbers, the prevention of crimes, and the deftruction of highwaymen. The accomplifhment of thefe objects is confidered in the royal grant as the difcharge of office to the fovereign; and on that account the word *office* (Khidmut) is employed in the Dewanny Sunnud for a Zemindary.

It was a rule in the times of the ancient emperors, that when any of the Zemindars died, their effects and property were fequeftrated by the government. After which, in confideration of the rights of long fervice, which is incumbent on fovereigns, and elevates the dignity of the employer, Sunnuds for the office of Zemindary were granted to the children of the deceafed Zemindar; and no other perfon was accepted, becaufe the inhabitants could never feel for any ftranger the attachment and affection which they naturally entertain for the family of their Zemindar, and would have been afflicted if any other had been put over them. For this reafon, the emperors, confidering it as a means of conciliating the minds of the people, gracioufly fixed and confirmed the children of the deceafed Zemindar in the office of their fathers and grandfathers, by iffuing new funnuds to transfer the poffeffion to them. By degrees Zemindaries became truly heritable property, which, however, could be transferred by gift or fale from one family to another. They could likewife be forfeited to the fovereign, by the Zemindar's deviating from his allegiance, neglecting to pay his tribute, or to difcharge the duties of his ftation.

It is univerfally known, fays Sir Charles Roufe Boughton, that, when the three provinces of Bengal, Bahar, and Oriffa, were ceded to the Britifh Eaft India Company, the country was diftributed among the Zemindars and TALOOKDARS (fee that article in this Vol.), who paid a ftipulated revenue, by twelve inftalments, to the fovereign power or its delegates. They affembled at the capital in the beginning of every Bengal year (commencing in April), in order to complete their final payments, and make up their annual accounts; to fettle

(A) This event took place towards the clofe of the 12th century. N. B. *Kherâje* fignifies fpecifically the tribute paid by a conquered country.

Zemindars. settle the discount to be charged upon their several remittances in various coins for the purpose of reducing them to one standard, or adjust their concerns with their bankers; to petition for remissions on account of storms, drought, inundation, disturbances, and such like; to make their representations of the state, and occurrences of their districts: after all which they entered upon the collections of the new year; of which, however, they were not permitted to begin receiving the rents from their own farmers, till they had completely closed the accounts of the preceding year, so that they might not encroach upon the new rents, to make up the deficiency of the past. Our author proves, we think completely, the right of the Zemindars to transfer their possessions, either by inheritance to their children, or, with the consent of the sovereign, to other families; and he argues strenuously and successfully against the bad policy, as well as injustice, of interfering with those rights, as long as the Zemindars discharge the duties of their several stations. Zemindars.

FINIS.

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Edinburgh:
PRINTED BY JOHN BROWN, ANCHOR CLOSE.
1801.